EVALUATION OF SMALL SCALE BURNING OF WASTE AND WOOD IN NOGALES, SONORA
Final Report

Bureau of Applied Research in Anthropology
University of Arizona

November 2007
(updated April 2008)

Cover Photo: Urban Rocket Elbow Stove created from the shell of a discarded washing machine

EVALUATION OF SMALL SCALE BURNING OF WASTE AND WOOD IN NOGALES, SONORA

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Executive Summary

Several studies conducted in Nogales, Sonora between 1999 and 2006 indicated that household-level wood and garbage burning was occurring and contributing to poor air quality there. Those studies provided a valuable baseline from which to develop this more comprehensive study of small-scale burning in order to provide the data needed for better understanding and responding to such burning. This study was conducted by researchers from the Bureau of Applied Research in Anthropology at the University of Arizona (UA) and funded by the Arizona Department of Environmental Quality, with assistance from the U.S. Environmental Protection Agency, to address two specific needs outlined in the 12-step *Plan of Action for Improving Air Quality in Ambos Nogales*: Recommendations F (Reduce Garbage Burning) and H (Reduce Wood Burning). The 12-step plan was developed by the Border 2012 Ambos Nogales Air Quality Task Force and Border Liaison Mechanism Economic and Social Development Subgroup in 2005. The researchers maintained communication with the Air Quality Task Force throughout the study, sharing the proposed research design, preliminary findings, draft action plan, and final study results and action plan.

To obtain the breadth and depth of information needed to understand small-scale burning in Nogales and to evaluate potential actions that can reduce burning and improve air quality there, this study was conducted in a sample of Nogales neighborhoods within which household surveys, interviews, focus groups, and participant observation were conducted. In addition, UA researchers conducted interviews with community leaders and government officials beyond the target neighborhoods to gain a more complete understanding of opportunities and constraints for addressing the significant challenges faced by residents that contribute to their decisions to burn wood and/or garbage.

To guide the design and implementation of the project and ensure that findings would be relevant and beneficial to local decision makers and residents, the researchers convened and worked with an Advisory Board comprised of government representatives from the *municipio* of Nogales, the state of Sonora, and the state of Arizona; employees of a Nogales recycling firm; neighborhood leaders; high school and college educators from Nogales, Sonora; a university researcher and graduate students from the UA; and an outreach specialist from a health-related NGO in Nogales, Arizona. This group provided a forum for formulating research questions, planning contextually relevant research, and generating discussion and feedback on the research process.

The researchers gathered data about factors associated with burning and prior efforts to reduce burning in order to identify and assess the potential success of alternative heating, cooking, construction, and garbage management technologies that can reduce small scale burning. In general, people in Nogales burn to address specific needs for managing solid waste, cooking, and/or heating the home. There are strong relationships among the location of a neighborhood, age of the neighborhood, garbage collection, and burning. In households where garbage burning was found to be occurring, individuals explained their actions either as a response to problems (lack of collection service) or as a preventive measure to avoid problems with dogs, insects, and illness. Study participants explained that wood was burned as an alternative or supplement to other sources of fuel in cookstoves and heaters. There is considerable variation in household

income levels within Nogales neighborhoods. This variation is reflected in the level and frequency of burning, especially of wood which depends to an even greater extent on the availability of individual household resources for purchasing alternatives than does garbage burning. These data and analyses served to guide the formulation of a course of action likely to eliminate or at least reduce public health risks associated with small-scale burning in Ambos Nogales.

A unique aspect of this study was the incorporation of small pilot projects within the study so that, rather than separating action from research, problems that were identified could be addressed and the response evaluated as part of the overall study. Therefore, as the study proceeded, various approaches were taken by the municipal government, educational institutions, and neighborhood groups to address these problems and the larger issues related to improving municipal solid waste management in the city. Based on the success of these measures and their potential for reducing burning, researchers then worked with members of the project Advisory Board and other municipal officials to develop an Action Plan for Reducing Burning in Nogales. The Action Plan involves eight specific steps: (1) Improve Garbage Collection and Street Cleanliness; (2) Increase Capacity and Improve Management of Landfill and Transfer Stations; (3). Develop a Program to Facilitate and Promote Composting; (4) Develop a Program to Facilitate and Promote Recycling; (5) Investigate and Develop Options for Increasing the Number and Type of Garbage Containers; (6) Develop and Promote Alternative No- or Low-Emissions Stoves; (7) Develop and Implement Education and Outreach Programs; and (8) Investigate the Use of Legal Measures and Fines to Deter Burning. As part of the Action Plan, researchers and members of the Advisory Board established timelines for completing each action, and identified resources and funding to ensure that the actions would be completed. All of the actions were underway by the end of the study and will require additional resources, personnel dedicated to ensuring that they are completed, monitoring, and updating in the coming months and years. In addition, continued support is needed for local initiatives to address the complex and inter-related challenges associated with the reduction of small-scale burning in Nogales.

Acknowledgements

This project would not have been possible without the financial support of the Arizona Department of Environmental Quality (ADEQ) and the U.S. Environmental Protection Agency and the continuous cooperation and help of many individuals, groups, organizations, and institutions in the states of Sonora, Mexico and Arizona, USA. More specifically, each aspect of this project required the collaboration—one that was often bilingual, binational, and inter-generational—of numerous people in Ambos Nogales and the surrounding areas. Our sincere thanks go to each and every individual who contributed to the efforts to understand and address the problems that lead to the burning of wood and garbage in Nogales.

In particular, we thank the members of the project Advisory Board: Romina Castanos Lopez (Dirección de Planeación del Desarrollo Urbano de Nogales), Javier Castillo (Relleno Sanitario de Nogales), Elizabeth Cota Mendoza (CONALEP y Fray Pedro de Gante), Irma Fragoso Rodriguez (Instituto Tecnológico de Nogales), Alma Jerez (TOM recyclers), Jesus Kataura (Southeast Arizona Area Health Education Centers), Elizabeth Lara Ruiz (CONALEP y Programas para Educación de Adultos), Yasbek Martinez (TOM recyclers), Jose Guadalupe Melendez Vazquez (Colonia Flores Magón), Edna Mendoza (ADEQ), Francisca Montanez Armento (Departamento de Salud de Sonora), Sarah Moore (UA), and Norma Pacheco (Colonia Flores Magón).

We also thank the representatives from Mexico's Secretariat of Environment and Natural Resources (SEMARNAT) and the Sonoran Secretary for Urban Infrastructure and Ecology (SIUE) as well as numerous municipal departments including Public Services, Public Works, Garbage Collection, and Fire, and the Coordinator of Citizen Participation. We are grateful as well for assistance from the leaders of several colonias, the trash collectors who graciously allowed the UA student researchers to ride along on their collection routes, and the various private and independent scrap collectors who shared information with us.

Also, we would like to recognize and show appreciation for the invaluable assistance and patience provided by the administrative staff at the University of Arizona's Bureau of Applied Research in Anthropology, especially Armando Vargas, Nancy Young, Kevin Oakes, and Maria Rodriguez, and to Dr. Drexel Woodson for sharing his insights and ideas with us.

Chapter One: Background of Study

Goals and Objectives of the Study

The purpose of this study is to examine small-scale burning and how it contributes to particulate matter and air toxics emissions in Ambos Nogales ("both" Nogales, composed of Nogales, Arizona, United States and Nogales, Sonora, Mexico), evaluate potential air quality improvements to be gained through local solutions, and assist local and state partners to develop a plan to reduce small-scale burning and the associated public health risks. Thus, the principal goal of this project is to assess small-scale burning activities in Nogales, Sonora in a manner that will support the development of a detailed course of action aimed at significantly reducing small-scale burning.

The Problem

Small-scale burning of wood and other combustible materials is known to contribute to elevated levels of particulate matter (PM) emissions in Ambos Nogales. Other sources of particulate matter include unpaved roads, hillside erosion, vehicle emissions, and industrial pollution. Scientists and policymakers are especially concerned about particulate matter generated in urban areas, where metals, carbon, ammonium, sulfates, nitrates, and organic compounds make up and become attached to the airborne particles and are then transported into human bodies via the lungs.

In Ambos Nogales, both cities regularly violate ambient air quality standards of their respective countries as a result of elevated PM levels. Those levels vary due to actions on the ground and also wind patterns; the highest concentration of small airborne particles have been found to occur in Nogales, Arizona in the morning and evening, when the winds are coming from the southeast (Anderson 2007). In Nogales, Arizona, PM_{10} (particulate matter 10 microns or less) levels rose consistently between 1995 and 2001, and despite a temporary decline, are on the rise again. The $150\mu/m^3$ standard for PM_{10} maximum 24-hour concentration has been violated consistently since 1998. In Nogales, Sonora, maximum 24-hour PM_{10} concentrations have exceeded the standard every year but one since 1997. In Nogales, Sonora, dangerous $PM_{2.5}$ (particulate matter 2.5 microns or less) levels have contributed to violations of the U.S. standard, though the 24-hour $PM_{2.5}$ levels have generally been within standard limits (ADEQ 1999).

Elevated levels of particulate matter have serious negative effects on human health, child development, and economic activity. Particulate matter has been identified as a key factor in respiratory illness and an asthma trigger in Ambos Nogales (Arizona Department of Health Services 2004). In general, particulate matter is linked to increased death rates among the elderly and people in poor health due to respiratory distress, higher rates of infection following particulate matter exposure, precipitation of acute cardiac events, and eye irritation and infections. Recent studies have shown that even young and healthy people are negatively affected by particulate matter. Lung damage occurs in the deep, thin-walled bronchioles of the lungs and results in fibrosis, a form of scarring, and abnormal thickening of the breathing passages, similar to the damage found in the lungs of heavy smokers (Andrew Churg in Raloff

2003). Growing clinical and epidemiological evidence indicates that the majority of excess PM-related deaths are attributable to cardiovascular disease (Lippmann 2003).

A specific concern for border communities such as Ambos Nogales, where the rates of diabetes are high, is that diabetics have been found to be particularly susceptible to the health effects of particulate matter. Diabetes can lead to severe cardiovascular disease and increased susceptibility to infection, and particulate matter aggravates both conditions. Based on several studies in U.S. cities, the risk among diabetics for hospital admissions associated with particulate matter was found to be double that of the general population (Zanobetti, Schwartz, and Dockery 2001; Zanobetti et al. 2002).

ADEQ (1999) estimates that PM emissions result in 8 to 14 percent increases in hospital admissions in Ambos Nogales and lead to a 3 to 5 percent increase in premature deaths in Nogales, Arizona and a 26 to 44 percent increase in premature deaths in Nogales, Sonora. Respiratory and cardiovascular illnesses can result in significant decreases in school and workplace attendance and, therefore, in the short- and long- term depression of economic activity. Indoor air pollution exacerbates the impacts of poor ambient air quality.

In Ambos Nogales, ADEQ (1999) identified road dust as the main source of PM_{10} and vehicular emissions as the primary source of hazardous air pollutants (HAPs), though concern about burning of wood and other combustible waste and scrap materials was high enough to lead to the development of an Action Plan to address these sources (see below). Recent analyses of PM in Nogales, Arizona document the presence of compounds common in plastic bags and indicate that garbage burning is a significant source of PM that accumulates there (Anderson 2007).

Wood burning is common in some neighborhoods in Nogales and increases during the winter at the same time that temperature inversions trap air pollutants close to the ground. In a review of studies on the impacts of household-level burning of biomass fuels (defined as wood, dung, and crop residues), Bruce et al (2000) found that smoke from biomass cooking fires has been shown to increase the risk of chronic obstructive pulmonary disease and acute respiratory infections in children, the most important cause of death among children under 5 years of age in developing countries. Biomass burning may also contribute to low birth weight, increased infant and perinatal mortality, pulmonary tuberculosis, nasopharyngeal and laryngeal cancer, and cataracts. "Exposure to indoor air pollution," they write, "may be responsible for nearly 2 million excess deaths in developing countries and for some 4% of the global burden of disease" (Bruce, et al 2000: 1078). According to the United Nations Development Programme (UNDP 2005: 6), "(I)ndoor air pollution…accounts for a greater share of lost life expectancy in developing countries than malaria, but receives little attention."

The Political Context

In 1993, the U.S. State Department established the Border Liaison Mechanism (BLM), a diplomatic instrument to achieve dialogue and coordination between sister cities on the U.S.-Mexico border. The BLM was designed with a flexible organizational structure to facilitate binational, intergovernmental collaboration at local, state, and federal levels. Nine BLMs, chaired by U.S. and Mexican consuls, operate in "border pair" cities and "have proven to be

effective means of dealing with a variety of local issues ranging from accidental violation of sovereignty by law enforcement officials and charges of mistreatment of foreign nationals to coordination of port security and cooperation in public health matters such as tuberculosis. In conjunction with the 1998 New Border Vision, the United States and Mexico agreed that each BLM would establish three working subgroups: Economic and Social Development, Protection/Migration and Border Crossing Facilitation, and Border Public Safety" (http://www.state.gov/www/background_notes/mexico_0899_bgn.html).

The Arizona-Sonora BLM is co-chaired by the U.S. and Mexican consuls serving in Ambos Nogales and addresses issues of interest in the border communities of the two states. Meetings are held approximately three to four times yearly, and the consuls invite various participants, primarily from the law enforcement, diplomatic, and municipal sectors, based on their interest in and potential contributions to the various agenda topics. Communication between these meetings is largely driven by specific projects (for example, implementation of the laser visa system), developing events (such as deaths among those attempting to cross the border into the U.S. without documents), and the overall missions of the agencies involved. To the extent possible, issues raised are resolved at the local level; when this is not possible, policy matters are elevated to the appropriate authorities.

In 1999, the U.S. and Mexican consuls in Ambos Nogales recruited the Arizona Department of Environmental Quality (ADEQ) and Secretaría de Infraestrucura Urbana y Ecología, Sonora (SIUE; Secretary for Urban Infrastructure and Ecology, Sonora) to assist them in establishing the Nogales BLM's Economic and Social Development Subgroup (BLM Subgroup) with the specific purpose of addressing the binational air quality problem in the region. Since its inception, officials from ADEQ and SIUE, together with the two consuls, have co-chaired this BLM Subgroup. The first task of the BLM Subgroup was to develop a set of recommended actions to improve air quality in Ambos Nogales. BLM Subgroup members proposed and accepted a set of operational ground rules and a method for reaching consensus on all group decisions (Austin et al. 2004). In the first phase, a series of informational sessions focused primarily on five aspects of the air quality problem in Ambos Nogales: residential emissions (primarily from wood burning and garbage burning), soil erosion, unpaved traffic areas, traffic congestion, and vehicle emissions. These problems were identified in a binational air quality study conducted jointly by ADEQ and Mexico's Secretariat of Environment and Natural Resources (SEMARNAT) and by local residents and environmental professionals (ADEQ 1999). The BLM Subgroup sought final recommendations that would include long-term solutions but would focus on well-defined options likely to have greater impacts in the short and medium term. After discussing the proposed revisions, the BLM Subgroup further refined the recommendations to distinguish "high" and "additional" priority items. Though high priority items were to receive greatest emphasis, the group recognized that some items on the additional priority list, especially those that might be easier and quicker to implement, should also receive attention.

In 2002, the U.S. Environmental Protection Agency (EPA) and SEMARNAT, in partnership with the U.S. Department of Health and Human Services (HHS), the Mexican Secretariat of Health (SS), and other federal agencies, created the Border 2012 program. Established with the participation of the ten border states and U.S. tribal governments, the mission of the Border 2012

program is to "protect the environment and public health in the U.S.-Mexico border region, consistent with the principles of sustainable development (EPA 2007). The legal basis for the Border 2012 program is the 1983 Agreement on Cooperation for the Protection and Improvement of the Environment in the Border Area (La Paz Agreement) which was signed in La Paz, Baja California Sur, Mexico, and empowers U.S. and Mexican federal environmental authorities to undertake cooperative initiatives. The ten-year Border 2012 program was designed to be implemented through multi-year binational programs with an emphasis on a locally-driven, bottom-up approach with the expectation that environmental issues in the border region will be best addressed by local decision-making, priority setting, and project implementation. EPA and SEMARNAT serve as National Coordinators for these programs. Regional workgroups assist in the identification and proposed resolution of border environmental problems. Then, local task forces, made up of representatives from paired states, are established and operate to address locally-identified needs. Five task forces were established in Arizona and Sonora: Water Quality, Air Quality, Children's Environmental Health, Emergency Response, and Hazardous Waste.

A Structure for Addressing the Problem

The Border 2012 program has six primary goals, two of which are to Reduce Air Pollution and Improve Environmental Health. Air pollution is clearly an ecological problem with severe public health and economic development consequences. To address the serious air quality problems of the region, in 2005 the BLM Subgroup in Ambos Nogales and the Border 2012 Ambos Nogales Air Quality Task Force came together to complete and finalize the 12-step *Plan of Action for Improving Air Quality in Ambos Nogales* (Border 2012 Ambos Nogales Air Quality Task Force and Border Liaison Mechanism Economic and Social Development Subgroup 2005). Air quality improvement recommendations outlined in the plan include a variety of actions aimed at reducing garbage and wood burning. This study addresses Recommendations F (Reduce Garbage Burning) and H (Reduce Wood Burning) of the Action Plan. Three suggested priority actions for reducing garbage burning include: (1) Improve garbage collection services in Nogales, Sonora, by extending regular, weekly service to colonias not currently receiving such service; (2) Conduct extensive public education to raise community consciousness about the importance of not burning garbage; and (3) Enforce laws against the burning of garbage more aggressively, including imposing fines. Because these actions were identified by the task force with only limited data available, the present study was designed to get more data on both garbage burning and what would be necessary to accomplish these priority actions and others necessary for reducing burning.

The goal of Recommendation H is to reduce the burning of wood and combustible waste materials through household-level actions that can be taken even without major investments in infrastructure and without significant changes to local and national policies. Two suggested priority actions for reducing wood burning include: (1) Provide device subsidies; and (2) Initiate thermally designed housing pilot projects. Again, the purpose of this study is to gather the data needed to make it possible to carry out these priority items and identify other means of reducing wood burning. These actions are expected to have significant impacts on both household and community-wide air quality, especially during the cold, winter months.

The focus of this study is Nogales, Sonora because the city is much larger than Nogales, Arizona and both garbage and wood burning occur with greater frequency there. Initial studies conducted in Nogales, Sonora, provide information about a variety of resident behaviors that affect air quality, including wood, coal, fuel oil, and garbage burning. A 1999 study by researchers at Arizona State University indicated that 23 percent of Nogales, Sonora households burned wood (Sadalla, Swanson, and Velasco 1999). However, because the study was designed to document pollution produced by workers brought to border communities by maquiladoras, insufficient data were collected about such factors as what was being burned, frequency and extent of burning, or seasonal cycles of burning, so the study is of limited help in identifying means for reducing the incidence and consequences of small-scale burning. For example, the researchers did not investigate links between household garbage burning and factors such as garbage collection. Neither did they examine the factors affecting the conditions under which residents burn materials for heating and cooking. Local officials and residents report more garbage burning in areas where garbage service is unavailable, but this link requires further investigation. Garbage burning sometimes occurs even in neighborhoods where regular collection services are provided three times each week.

A pilot study investigated the potential for reducing burning for cooking and heating through the introduction of efficient and low emissions technologies and through more thermally efficient construction (Austin et al. 2006). However, that study was conducted in only two colonias and the relevance of their findings across the municipality is unknown. Furthermore, the focus of that study was on the introduction and acceptance of new technologies, so limited data about burning were collected.

Potential to Reduce Garbage Burning

Burning garbage is one approach to reducing or eliminating the presence and potential negative impacts of garbage within a household, neighborhood, or city. With its focus on households and small businesses, this study addresses a portion of the wastes defined in Mexico as municipal solid wastes (MSW): those coming from activities carried on in homes, places of public and private service, buildings, and commercial and service establishments that are not considered dangerous due to their chemical and physical nature (SECOFI 1985, Bernache et al. 2001).[1] In Mexican urban settings, residential wastes make up the main component of MSW (Castillo, 1990; Phillips et al., 1984; Rathje et al., 1985; Restrepo et al., 1991; Ramírez and Chávez, 1998; Arias et al., 2001; Buenrostro, 2001). Consequently, it is reasonable to expect that addressing household garbage burning within the context of a broader program of MSW management will have an effect on air quality as well. The following paragraphs provide information about solid waste management in Mexico; details about Nogales can be found in Chapter Two and the remainder of this report.

Ojeda- Benitez and Beraud-Lozano (2003) identified three types of sites in which the disposal of MSW occurs: (A) Controlled/sanitary landfill. These are sites destined for the final disposal of

[1] SEDESOL defines municipal solid waste as that which is generated in households, parks, markets, stores, facilities, demolition sites, construction sites, institutions, general services establishments and all those participating in municipal activities that do not require special control techniques (National Institute of Statistics, Geography and Computer Sciences, INEGI, 2002, cited in Ojeda- Benitez and Beraud-Lozano 2003).

MSW that have partial inspection, supervision, and application of necessary measures to comply with the established regulations. These disposal sites have to comply with Official Mexican Norm, NOM-083-SEMARNAT-2003, which establishes the conditions required by the sites destined for final disposal, including restrictions to avoid affecting construction sites and protected natural areas, required minimal distance to airports, roads, railroads, hydrological, geological, and hydro-geological aspects and the application of equivalent technologies and systems. (B) Uncontrolled dump. These are sites where different types of MSW are disposed and mixed without any control. (C) Open dump. These are sites where MSW is disposed and accumulated illegally without any technical control. Common sites include deserted lots, ravines, rivers, creeks, and other bodies of water. In 2003, the most recent year for which data are available from SEDSOL/INEGI, 56 percent of Mexico's MSW went to sanitary landfills, 11 percent went to uncontrolled dumps, and 33 percent went to open dumps (INEGI 2006a).

Improvements in waste management require attention to human behavior and local waste characteristics and can derive from applying research results to the definition, design, and implementation of a management plan that involves non-governmental sectors, as well as municipal, state, and federal governments (Buenrostro and Bocco 2003). In general, the trend in waste treatment and handling technologies in many countries is to increase diversion of waste from landfills (Fehr et al. 2000).

In Mexico, the management and final disposal of solid waste are the responsibility of both states and municipalities. Each municipality is responsible for providing free public sanitation service via the collection and transportation of solid waste. In general, this service is limited to those wastes that are catalogued as MSW, though there has been some confusion over the definition of solid waste and municipal solid waste (Buenrostro and Bocco 2003). In addition, the federal government, through the National Institute of Ecology (INE), can promote coordination and consultancy agreements with both states and municipalities to develop and improve collection, recycling, treatment, and final disposal of municipal solid waste (Ojeda-Benitez and Beraud-Lozano 2003). Between 2000 and 2003, the latest years for which data are provided by the Secretaría de Desarrollo Social (SEDESOL) via INEGI, official estimates are that between 83 and 87 percent of the total amount of municipal waste generated is actually collected (INEGI 2006a). Those figures have remained fairly constant over time (SEDESOL 2000, cited in Ojeda-Benitez and Beraud-Lozano 2003; INE, 1999; cited in Armijo de Vega et al. 2003), and are similar at the level of individual cities as well as the national average. In Nuevo Leon in 1998, for example, less than 85 percent of the estimated total refuse generated in the city was collected (Medina 1998). There, uncollected waste was found illegally dumped in vacant lots scattered throughout the city or in creeks that feed the Rio Grande. Information about Nogales' MSW program is provided in Chapter Three of this report.

Production of Garbage from Households and Small Businesses

Review of the relevant literature reveals diversity in waste composition from one country to another, between urban and rural areas, and even from one city to another. Without a waste characterization study, it is not possible to determine the specific amounts of waste generated in Nogales. Nevertheless, data from other studies provide an indication of the types of materials found in municipal solid waste and changes in volume and composition over time.

Unfortunately, many of those studies lack any analysis of waste management programs and information on how to get programs to work better.

The amount and type of solid wastes generated in any community is related to population size, levels of consumption, level of technological development, and characteristics of the products that are consumed; for example, processed goods are associated with higher levels of packaging (Bernache 2003). In Mexico, related factors affecting solid waste generation are the amount of the land under settlement; heterogeneity in consumer patterns; uneven and rapid industrial growth; migration from rural to urban areas; the lack of planning; social, economic, and cultural status; and the influence of United States consumer patterns, especially in border communities (Ojeda-Benitez, Armijo de Vega, and Ramírez-Barreto 2000). A recent study found that 56 percent of the municipal waste in Guadalajara comes from homes, with the other 44 percent from a variety of sources including public parks, markets and streets; governmental institutions, schools and universities; and commercial centers. Industrial, non-hazardous wastes were found to be only a minor part of the total because of high rates of recycling of such wastes as cardboard, wood, and plastic, mostly by small recycling firms (Bernache 2003).

Mexico is experiencing an urbanization process in which approximately 70 percent of the population is concentrated in its ten largest cities; the rest are spread throughout 200,000 towns. This has caused a change in the population's consumption patterns and has resulted in a more heterogeneous composition of solid waste and an increase in its generation rate. SEDESOL divides the country into five geographical zones for purposes of evaluating waste management: (1) border with the United States, which extends up to 100 km to the interior, (2) northern, (3) central, (4) southern, and (5) Distrito Federal. Data from INEGI and SEDESOL (see Table 1.1) indicate that Mexico City has the largest waste generation per person, followed by the U.S.-Mexico border region; within the border region the amount of waste produced per person per day is just over 1 kilogram. In the country as a whole, the production of waste per person per day increased three-fold between 1975 and 1999; the population increased in the same period from 30 to 98 million people (INE 1999). Data from SEMARNAT (2001) show a 200 percent increase in municipal solid waste generation per person since 1960 with increased consumption of processed goods playing a major role. A study of the role of packaging in Mexico City conducted by Rathje et al. (1985), for example, reported that packaging made up 20 percent of the total household wastes (though still lower than the 40 percent found in U.S. households).

Table 1.1. Production of Municipal Solid Waste in Mexico, 2005, according to Geographical Zones

Region	Production (kg per person per day)	Annual production (tons)	Percentage of total waste produced
Border	1.048	5,591,800	15.8
Center	0.882	17,795,575	50.3
Federal District	1.414	4,549,725	12.8
North	0.774	3,912,800	11.0
South	0.697	3,533,200	10.0
National	0.911	35,383,100	100.0

Source: INEGI (2006b). Con base en SEDESOL. DGOT. Subdirección de Asistencia Técnica a Organismos Operadores Urbanos Regionales.

Data on household waste are generally obtained by collecting and sorting waste into material composition categories and then weighing the waste and recording the information collected. In Mexico, garbage studies have shown significant variation in the generation of household waste per person. Several studies conducted in the 1980s and 1990s concluded that almost half of the sample refuse from Mexico City was food debris (Rathje et al. 1985; Phillips et al. 1984; Restrepo and Phillips 1985; Castillo 1990; Restrepo et al. 1991), though in general the composition of the waste stream has shifted with primarily organic, easily biodegradable material being replaced by substances with a slow decomposition rate (Ojeda-Benitez and Beraud-Lozano 2003). These findings locate Mexico between the United States, where only about 20 percent of household waste comes from food and organic matter, and countries like Brazil, where a waste characterization in the city of Uberlándia, located in the central part of the country, indicated that 72 percent of the waste, by weight, consisted of biodegradable organic matter (Fehr et al. 2000). In a recent study in Guadalajara, most of the waste was found to come from the kitchen in the form of peelings, bones, seeds and other by-products of food preparation processes starting from fresh produces and raw ingredients (Bernache et al. 2001). In that study, about 41.6 percent of the waste coming out of households was kitchen organic wastes and another 12.2 percent came from garden and plants maintenance (grass clippings, small branches, dry leaves, and the like). Paper and cardboard made up 10.6 percent, plastics 9.6 percent, glass 4 percent and metals 1.5 percent of the overall weight. Other categories which contributed less than 5 percent each but were found to be important were rigid plastic containers, plastic film and bags, transparent glass, and cardboard.

With respect to the final disposal of solid waste, almost all continues to be managed in open-air dumps, non-controlled landfills, and sanitary landfills (Buenrostro and Bocco 2003). The majority of sanitary landfills in Mexico do not comply with existing environmental laws. There is little control over the solid waste that is deposited in the landfills and the daily covering of wastes is inadequate. Still, during the period from 1992 to 1998, the amount of solid waste collected increased by about 18 percent. On average, Mexican municipalities direct around 6 percent of their annual budget toward public sanitation (SEDESOL 1999, 1995, cited in Buenrostro and Bocco 2003).

Burning Seen as Response to Inadequate Service

In general, the type and quality of garbage collection service has been found to be linked to distance from the city center, with neighborhoods that are further away receiving less regular service. For example, in Tlaquepaque and Tonala, marginal neighborhoods on the outskirts of the urban center receive waste collection service once a week or less (Bernache 2003). In those cities, inefficiencies in collection and transportation of municipal solid waste exacerbate existing problems; with only two functional transfer stations, as many as 77 percent of the collection trucks operating in the metropolitan area have to travel long distances to take their load directly to the municipal landfills. In Nuevo Laredo, waste collection was occurring once a week, which residents considered insufficient to their needs (Medina 1998). Residents of neighborhoods not served by municipal collection often burned their refuse in their backyards, in front of their homes, or in the nearest open space.

Changing Management Practices

Unlike the majority of waste management studies that focus on diverting waste from landfills, this study is concerned primarily with improvements in the collection and disposal of waste in order to decrease the burning of garbage at homes and small businesses. Consequently, this study pays greater attention to the system of trash collection than to what is happening at the landfills. At the same time, diversion of materials from the landfills can lead to cost savings throughout the system and thereby increase the resources available to other aspects of the waste management program. In Brazil, researchers examined the separation of humid (biodegradable) from dry (inert) waste and concluded that a successful program could divert 84 percent of solid household waste from landfills, which would drastically reduce waste handling costs. However, they also concluded that such a program would nevertheless create an enormous managerial challenge and represent a radical change in environmental management in the region (Fehr 2000; see also Calçado 1998).

Waste management strategies that specifically focus on reducing the volume of waste entering landfills often aim to increase waste recycling and reuse through adequate management, new markets, and more effective systems. Waste must be carefully managed for recycling because mixed collection and compacting during transport can lower the quality of potentially recyclable components and therefore their economic value (Fehr 2000). Other municipal waste management technologies designed to reduce waste going to landfills include incineration, composting and anaerobic digestion, selective collection of only some items, and post-collection separation. Selective collection from households has been found to be inefficient because waste collectors are required to sort through the waste as they collect it; inefficiencies result from the time required to sort the waste en route, the amount of material that could be separated but is overlooked in the process, and the contamination of potentially recyclable or reusable items (Fehr 2000).

In their studies of solid waste management in Mexican municipalities, Buenrostro and Bocco (2003) identified several problems that required attention: (1) lack of suitable solid waste collection equipment (i.e. those that are not suited to the type of waste being collected or produced); (2) incorrect design of the collection route; and (3) miscalculation of the void space required for sanitary landfills. Yet, efforts to change municipal solid waste management strategies face significant challenges. Bernache (2003) has identified four reasons for the absence of more sustainable waste management practices: (1) municipal authorities do not consider that economic investment in municipal solid waste management has political value; (2) environmental and sanitation department authorities have limited experience and little specialized knowledge on environmental issues; (3) workers have little or no motivation or incentive for change; and (4) those responsible for the programs have little knowledge of possible technological innovations.

Potential for Recycling

In a recent study in central Brazil, researchers found that separation of recyclables at the household level would divert a relatively insignificant part of household waste and would have high costs both in terms of infrastructure and educational efforts making street collection of items that had been separated for recycling economically infeasible (Fehr 2000: 253). The

researchers therefore focused on creating an efficient industrial recycling or reuse system. However, studies describing the composition and final disposal of household solid waste in Mexico have found that a significant amount of this waste could be recycled (Buenrostro et al., 2001; Bernache-Perez et al., 2001; Gaxiola, 1995; Ojeda-Benitez et al., 2000). In one study, the profile composition of the 69.6 daily tons of separated materials sold to recyclers in Guadalajara consisted of 35 percent glass contributes, 30 percent plastics, 10 percent paper and cardboard, and 10 percent metals (Bernache et al., 2001). The profile changed according to variations in market prices, seasonality, and other factors.

Other researchers, too, have found that the majority of Mexican household waste is potentially recyclable or compostable. However, lack of separation and of local facilities that accept recyclable and organic wastes reduce the amount of materials that are actually recycled or composted. In a study in Mexicali, for example, Ojeda-Benitez et al. (2000) found that within the *colonia* they were studying, 18.6 per cent of the total waste collected could be recycled locally, 68 per cent was potentially recyclable (but there were no recycling industries in the area), and 13.3 per cent could not be recycled.

Participation in Recycling Programs

Many cities and communities across the globe have attempted to initiate recycling programs. As in other aspects of municipal solid waste management, it has proven necessary to design programs to promote recycling and reuse behaviors that respond to the specific characteristics and needs of each community. An integrated view of all waste diversion activities is necessary because changes in one aspect of a waste management program will affect others as well. As noted by Martin, Williams, and Clark (2006), recent research on recycling has focused on recycling awareness, participation, and behavior; designs of recycling schemes; economic incentives to encourage recycling; effective publicity and promotion; and cultural factors. Unfortunately, the information that is published is complex and often contradictory and difficult to interpret, which creates significant problems for those responsible for developing waste strategies and policies. The aim of this section is to discuss research findings that are relevant for Nogales.

Household recycling requires people willing to recycle and the supporting infrastructure for them to do so. People participate in recycling programs, but generally only if the local recycling services are reliable and convenient. In survey research, self-reporting of recycling behavior tends to be exaggerated, sometimes by as much as 50 percent (see Martin, Williams, and Clark 2006). For example, Perrin and Barton's (2001) study of the implementation of two curbside programs found that the most common reasons people gave for not recycling before the programs were put in place were inconvenience/lack of time, distance to recycling centers, and storage/handling problems. However, the curbside programs generated only half the recyclables expected, suggesting that the other previously less important reasons such as 'insufficient recyclables', 'too much effort' and 'apathy' also influenced residents' behavior. The provision of regular feedback to householders regarding recycling services and the performance of both the individual household and the overall program has proven to be important to the success of recycling programs (Martin, Williams, and Clark 2006).

The wealth of the household has been found to affect whether or not its members participate in recycling and reuse programs. For people with few resources, reuse and recycling are often undertaken not as pro-environmental actions but as practices of subsistence, habit, or preference. Chung and Poon (1999, 2001) for example, found that in China people of lower socio-economic status recycled most because they were able to benefit financially from selling the recyclables. In a recent study to investigate personal and situational predictors of reuse and recycling behaviors in Hermosillo, Corral-Verdugo (2003) found that physical situational factors such as having space for storage of objects, size of household or yard, and the presence of cabinets for saving objects were determinants of conservation practices, especially of reuse behaviors. Thus, households with more resources tended to recycle more; people in extreme poverty who did not possess much had little to reuse or recycle. For people living in a moderate state of poverty, the researchers determined that success in promoting environmental behavior was tied to whether people had opportunities such as good employment, economic support, education, and job training that allowed them to improve their economic situation.

In other studies as well, lack of storage has been seen as a major barrier to recycling due to the conflicting claims on storage space both inside and outside the home. The need for adequate space for extra bins both inside and outside makes it challenging to create an equitable program when people are charged money for failure to participate in the recycling program or are offered rewards for their participation (Martin, Williams, and Clark 2006). Researchers noted that many households would not have the space to be able to take advantage of comprehensive recycling in order to either offset fines or charges or to earn rewards.

In many communities, scavengers recover and recycle a large quantity of materials, often in larger quantities than what is obtained in the formal programs of developed countries (Buenrostro et al., 2001, Trejo-Vázquez and Cespedes-Soto 1989). When communities implement recycling programs, they must recognize and account for the presence of the scavengers, both to protect the interests of individuals whose livelihoods depend on having access to the materials and to recognize that scavengers will glean the most valuable materials and reduce the potential for producing income from the overall program. For example, Bernache (2003) reported that scavengers working at the city's dump site and sanitation workers assigned to collection trucks were the most effective agents for separating MSW in Guadalajara.

Medina (1998) studied recycling programs in Laredo and Nuevo Laredo and found that informal recycling of aluminum cans alone involved over 3,000 individuals who were collecting the cans and also provided work opportunities for 74 employees who handled and processed the recyclables at scrap dealers. In those communities, three types of individuals were responsible for the recovery of approximately 75 percent of the aluminum cans consumed by the population of the area: dumpsite scavengers, street scavengers, and people in homes and small businesses who separated their cans. He found that a persistent problem for the Laredo recycling program was the theft of aluminum cans by scavengers, who simply gathered the cans from the containers designated for recyclables before the collection crews arrived. Buenrostro and Bocco (2003) have observed that the presence of increasing numbers of scavengers is tied to both population growth and income inequality in Mexico and that dumpsite scavengers operated under social and environmental conditions that made it very difficult for them to improve their economic level. Though these groups often have variable membership, which can make it difficult for

government leaders to work with them, it is important that they be included in decision-making processes regarding solid waste management, because of their knowledge and success, and their economic vulnerability (Buenrostro and Bocco 2003).

Some studies have shown that the type of containers provided makes a difference in whether or not people participate in recycling programs. For example, Everett and Peirce (1993) found that in the United States rigid containers were perceived to be more convenient and produced higher recovery rates than sacks, and Price (2001) found that in the United Kingdom the introduction of wheeled bins led to an increase in general waste volumes. Transparent containers to allow for verification of the contents have been successfully used in some places (see below under composting).

A number of studies have attempted to determine whether voluntary or mandatory programs get better results, but the findings have been mixed. In either case, once designed, programs are not effective without concurrent community and municipal campaigns for the collection and also sale of recyclable refuse and education campaigns that provide information about how to participate.

Recycling Programs in Educational Institutions

Educational institutions are often targets for recycling programs because recycling is among the most visible, measurable, and enforceable of the environmentally sound practices that a campus might undertake, but few programs have been studied to determine their effectiveness. Based on experience at the Universidad Autónoma de Baja California, Armijo de Vega et al. (2003) determined that waste management program coordination requires the cooperation of all sectors of the campus: directors of grounds maintenance, custodial services, food services, superintendents of laboratories, libraries and classroom buildings, leaders of student organizations, and environmentally minded faculty members. Once started, the program must be monitored carefully and the campus population told of progress or setbacks. Education and motivation must be directed at all the university's community including high ranking administrative and academic staff. To be successful, educational institutions must:

- Train teachers about waste management and recycling;
- Produce activities for waste reduction in the institution;
- Separate wastes produced in the institution;
- Encourage students to participate in short projects about recycling and reducing activities;
- Encourage students to visit recycling centers and municipal landfills.

Composting

Organic material causes special problems for MSW management so many municipalities have tried to develop programs to deal with it. Separation of organic matter from recyclables has been identified as critical in a comprehensive program to avoid contamination of the recyclable materials. In Tucson, for example, food-contaminated materials (e.g., unwashed cans or bottles) cannot be placed in the recycling containers, regardless of whether the materials themselves would be recyclable otherwise.

Fehr (2000) developed a model for an urban area in Brazil that focuses on the separation of organic (humid) and dry waste at the household level. The model requires the use of two receptacles at each household, one for biodegradable waste and the other for all the rest. Such separation was included to eliminate problems with bad odors and sanitation because the humid waste was enclosed in plastic bags and discarded daily for collection. The dry waste could then remain stored for longer periods without causing problems. The model was implemented in two condominiums, one with 48 and the other with 12 apartments, in order to show its functionality, measure the results, and determine how much of the organic waste was recovered. First, the system was explained to all residents. The resident were instructed to collect biodegradable matter separately in transparent plastic bags such that it could be directed to composting operations with a minimum of further sorting. Initial sorting revealed the presence of considerable amounts of humid waste in the fraction called dry by the residents, but with each successive iteration, accompanied by feedback to the residents, the fraction of humid waste that was separated out increased. The results indicate that with enough support the residents were able and willing to change their behavior. The researchers estimated that expansion of the program to larger condominium units would require additional time; they estimated that a complex of 120 apartments would require the equivalent of 8 person-months to implement. The human as well as physical needs of an urban composting program would require attention in Nogales as well.

Need for Education

The success of any recycling and composting programs has been tied to education and outreach efforts. There is a growing movement to emphasize the importance of developing environmental awareness across Mexico's school population (Barraza 2001), though a major bottleneck of education in general, and environmental education in particular, has been teacher training and sensitivity about environmental matters. Buenrostro and Bocco (2003) have observed that it is important to develop mechanisms to improve the cooperation between the Ministry of Education and the Ministry of Environmental Protection in the development and implementation of environmental education programs, both to make the general society more conscious about the implications and causes of solid waste production and to put pressure on the different levels of government to deliver coherent policies. Corral-Verdugo (1996, 2003) found that watching commercial TV correlated with a decreased reuse effort in Mexican communities, and in some instances also with lower participation in recycling and therefore recommended that special efforts for delivering pro-environmental messages through written and electronic media should be undertaken in the community.

Potential to Reduce Burning for Household Heating and Cooking

Wood is used for heating and cooking throughout the world, primarily because it is an available, affordable, and easy to use fuel source. The United Nations Food and Agriculture Organization (FAO) estimated in 1983 that three-fourths of the developing world's population depended on wood and other forms of biomass for heating and cooking, including surprisingly large numbers of people in urban areas (FAO 1983).

Driven by the social, economic, and ecological problems accompanying deforestation and wood shortages, the search for efficient alternatives to standard wood-burning technologies has proliferated. In addition, concern over the negative health effects of household cooking over open fires and its contribution to poor indoor air quality has led to numerous studies of the impacts, as well as efforts to find low-emissions alternatives. In many parts of the world, such studies have focused on rural communities (see Masera, Diaz, and Berrueta, 2005; Zuk et al., 2006). While many Nogales, Sonora households share characteristics of their rural counterparts across Mexico where wood is commonly burned for heating and cooking, many differences are also apparent. Information about household wood burning in Mexico and its consequences is provided below; details about Nogales are provided in the other chapters of this report.

In Mexico as in other parts of the world, most studies of wood burning and the potential benefits of alternative stoves has been done in rural areas. For example, in the village of San José Solis, near Mexico City, Brauer et al. (1996) measured PM concentrations in eight kitchens using only biomass, six using only liquefied petroleum gas (LPG), six using a combination of biomass and LPG, and three using biomass in ventilated stoves. They collected both outdoor and indoor air samples and found that for both average and peak concentrations, PM10 and PM2.5 concentrations in the kitchens burning only biomass were significantly higher than in those using all other types of stoves. A decade later, Regalado et al. (2006) conducted a cross-sectional survey of cooking fuel use and respiratory symptoms and illnesses with 841 lifelong non-smoking women in the village of Solis. The researchers also performed spirometry in the women's homes and measured particulate matter concentration in the kitchen for one hour while the women were cooking. The researchers found high peak indoor concentrations of particulate matter in homes of women cooking with biomass fuels and, compared with those cooking with gas, the women showed increased respiratory symptoms and a slight average reduction in lung function.

Studies examining alternative wood stoves have also been focused in rural areas. For example, Zuk et al. (2007) evaluated the impact of improved wood burning stoves on indoor air pollution in 53 homes in a rural town in Michoacán. They measured fine particulate matter less than 2.5 microns in diameter in the central plaza of the community and in three microenvironments in the home (next to the stove, in the kitchen away from the stove, and on the outdoor patio). They then distributed improved wood-burning stoves, which were designed to emit less particulate matter, and measured $PM_{2.5}$ concentrations again. A significant finding of their study was that even occasional use of the alternative stove (in comparison with cooking over open fires) led to reduced daily average personal exposures to $PM_{2.5}$. Thus, though only 44 percent of the participants reported to use the alternative stoves exclusively during the study, participants' average daily exposures were reduced by 50 percent. The findings from such types of studies indicate that attention to investigating the incidence of the use of wood stoves and the potential for reducing particulate matter concentrations and associated negative health effects in Nogales households is warranted.

Outline of Report

An evaluation of small scale burning and development of a plan of action requires an assessment of burning behavior – where and why it is occurring – and also an assessment of forms of

governance that would be appropriate for Nogales. Chapter Two describes the methods used to collect and analyze information in this study. Chapter Three provides background on Nogales, Sonora, focusing on its growth and development, structures for the provision of waste collection and management services to its residents, mechanisms for cooking, and home construction and heating. Chapter Four presents the results of surveys, focus groups, interviews, and participant observation that were used to investigate burning that is occurring in the city – the who, what, where, when, and why of both garbage and wood burning. Chapter Five discusses possible means for reducing burning, examining what has been tried in the past and the successes and failures of those efforts, as well as the recommendations of people who participated in this study. The chapter concludes with a discussion of responses that are most likely to reduce small scale burning in Nogales and the forms of governance necessary for achieving positive results. Chapter Six presents an Action Plan for reducing small scale burning. Each action is considered separately and includes a discussion of the links between the action and the ultimate goal of reducing burning and improving air quality, the entities responsible for carrying out the action, the information and resources needed for implementing the action, and a timeline for completing the action.

Chapter Two: Study Methodology

Initial studies of small scale burning conducted in Nogales, Sonora (Sadalla, Swanson, and Velasco 1999, Austin et al. 2006) provide a valuable baseline from which to develop a more comprehensive study of small-scale burning, but they are insufficient for determining where and why such burning is occurring and for identifying potential mechanisms by which the burning can be reduced. This project was designed to gather data about factors associated with burning (e.g., neighborhood characteristics, availability of garbage collection, household income) and assess the potential success of alternative waste management, heating, cooking, and construction technologies for reducing small scale burning. This chapter describes the methodology for gathering and analyzing data and using the results to develop an action plan to reduce small scale burning in Nogales, Sonora.

The purpose of this study was to develop and provide initial evaluation of an action plan to reduce small-scale burning, so the researchers focused on collecting data that would be sufficient for providing an understanding of where, when, and how small-scale burning was occurring in Nogales in order to find ways to reduce the burning, rather than to determine the total amount of burning. Consequently, a mixed methods approach was selected, with the attention to more comprehensive data collection and analysis in a selection of neighborhoods across Nogales rather than equal representation across the city.

Project Advisory Board

As described in the previous chapter, small scale burning in an urban area can result from the lack of adequate infrastructure for collecting and managing solid waste and for providing affordable fuel for heating and cooking. The provision of infrastructure is the responsibility of governments, commercial enterprises, and sometimes non-governmental organizations (NGOs). Information about the roles of these various entities and how such infrastructure functions is often disseminated through educational institutions. Any change in the system will likely require the active participation of representatives from all these sectors. Therefore, the study began with the formation of an Advisory Board consisting of government representatives from the *municipio* of Nogales, the state of Sonora, and the state of Arizona; employees of a Nogales recycling firm; neighborhood leaders; high school and college educators from Nogales, Sonora; a university researcher and graduate students from the University of Arizona (UA); and an outreach specialist from a health-related NGO in Nogales, Arizona. This group provided a forum for formulating research questions, planning contextually relevant research, and generating discussion and feedback on the research process.

Initial research was undertaken to explore the relationship of burning to household- and neighborhood-characteristics, such as access to infrastructure and services. The study was designed to include: (1) a household survey; (2) a restaurant survey; (3) a questionnaire; (4) focus groups and interviews with neighborhood residents, small business owners, and community leaders; (5) direct and participant observation in municipal waste management activities; (5) direct participant observation in households where burning does and does not occur; (7) the development of a draft action plan; (8) pilot testing of the activities included in the action plan; and (9) finalization of the action plan. The Advisory Board reviewed, modified, and

approved the overall study plan; approved the sampling strategy; helped design the survey; reviewed preliminary results and suggested modifications; helped generate questions for interviews and focus groups; identified potential interviewees; helped researchers gain access to government and business leaders; reviewed and modified the draft action plan and results of the pilot testing; and approved the final action plan.

Sampling

With the help of the Advisory Board, the UA researchers determined an appropriate sample. Nogales, Sonora presents several specific challenges due to its size, variable population densities, topography, and rapid growth. Based on experience and data from the earlier studies, the researchers and Advisory Board members expected to find higher incidences of burning of both garbage and wood in low income households. However, Nogales residents, especially people living in the marginal colonias, are underrepresented in the official national population survey conducted every ten years by the Instituto Nacional de Estadísticas, Geografía Informática (INEGI). Nevertheless, for the neighborhoods that are included in the census, a preliminary assessment of the correspondence of the INEGI data and conditions within the colonias, led the research team to determine that INEGI's poverty index was the best variable to use for creating categories of units; it is constructed at the neighborhood level from a weighted average of illiteracy, primary occupation, water scarcity, plumbing scarcity, electricity scarcity, earth floor, and crowding (Pick and Rebeil 2003).

Data about various neighborhood characteristics were entered into a Geographic Information System (GIS) database as layers. Maps of Nogales were shared with members of the Advisory Board and members pointed out that even the most recent versions of the maps, generated using data from the city, state, and federal governments, lacked some of the more established colonias, while other newer neighborhoods were included in the map. The initial discussion of maps catalyzed a lively discussion about perceptions of particular areas, how these perceptions actually 'mapped-on' to reality, the validity of suggested correlations between vague measures of socioeconomic status and propensity to burn, and more. The visual presentation of preliminary maps helped open a dialogue with the Advisory Board members. Discussions about the misrepresentation of neighborhoods and the people who live in them highlighted both the scientific and the political implications behind the designation of being at-risk or of higher propensity to burn garbage. These early discussions also set the stage for how the Advisory Board would help define and contribute to the study throughout its implementation. Information from the Advisory Board meetings was incorporated into the findings of the study, as appropriate. After the first meetings, the maps were updated to ensure that all colonias were included. Census data were available at a parcel level for most of the city extent, so these data were aggregated into the polygons represented by the new colonias (or rather, the newly demarcated colonias). The problem was not a lack of overall census coverage but of accurate colonia boundaries because the administrative boundaries recognized by the communities were not included in the GIS data layers. Once the new colonias were identified, census data were incorporated into the GIS database, and areas with no census data (or poverty index) were assigned a null value.

The researchers determined that the most effective approach would be to select a sample of Nogales neighborhoods and conduct household surveys, interviews, focus groups, and participant observation within these neighborhoods, and then use the information they learned to design the action plan appropriate for the entire city. Sadalla, Swanson, and Velasco (1999) conducted a survey in only the marginal colonias on the edges of Nogales; based on a random sample of 400 households in those colonias, they found that 23 percent of the households reported that they burned wood and 26 percent reported that they burn garbage on a regular basis. A challenge for this study was to include all types of neighborhoods yet ensure sufficient representation of the neighborhoods where burning was expected to be more frequent. The method of adaptive cluster sampling was determined to be the most suitable for this study because it is particularly appropriate for identifying populations that are rare, unevenly distributed, hidden, or hard to reach (see Thompson 1991, Thompson and Collins 2002). In this approach, sampling units are categorized according to a relevant variable and then selected to ensure that all categories are represented in the final sample.

After some trial and error, the researchers settled on AGEB units (Áreas Geoestadísicas Básicas, similar to U.S. census tracts) as the most appropriate sampling units. An AGEB is a basic areal unit created by INEGI that ranges in size from 25 to 50 blocks and includes around 2,500 inhabitants. Within Nogales, there are about 90 AGEB units with fairly decent levels of homogeneity, a necessary factor in any type of cluster sampling. Using Jenks' method of natural breaks, for which data are assigned to classes based upon their position along the data distribution relative to all other data values, along with the 2000 INEGI data, the researchers began by dividing the AGEB units into three categories to increase the level of homogeneity within each. The resulting three categories were: less than 25 percent of the households within the AGEB unit at the poverty level; 25 to 49 percent of the households at the poverty level; and greater than 50 percent of the households at the poverty level (see Figure 2.1). The category with the lowest proportion of households in poverty included 62 AGEBs, the middle category included 27 units, and the one with the highest proportion of households in poverty included 10 units. The researchers then randomly selected four AGEB units within each category, resulting in a total of 12 AGEB units.

Household Survey

With the assistance of the Advisory Board, the UA researchers designed a survey that they used to gain quantitative information about what was happening in each of the 12 randomly selected AGEB units. Using maps that showed all the AGEB units on one side and then highlights of the AGEB units that were randomly selected on the other, the researchers located the AGEB units within the city and identified the boundaries of those units. The process was pilot tested by all researchers, questions were discussed and problems resolved, and final maps were produced for the research team. As dictated by the adaptive cluster sampling approach, after a first round of surveying, once colonias where significant amounts of burning are taking place had been identified, if necessary for sufficient representation of households who reported burning, researchers would randomly select an additional 60 households from within those colonias to complete the survey. As it turned out, the first round of surveys provided sufficient representation of households reporting burning, so surveying stopped at that point.

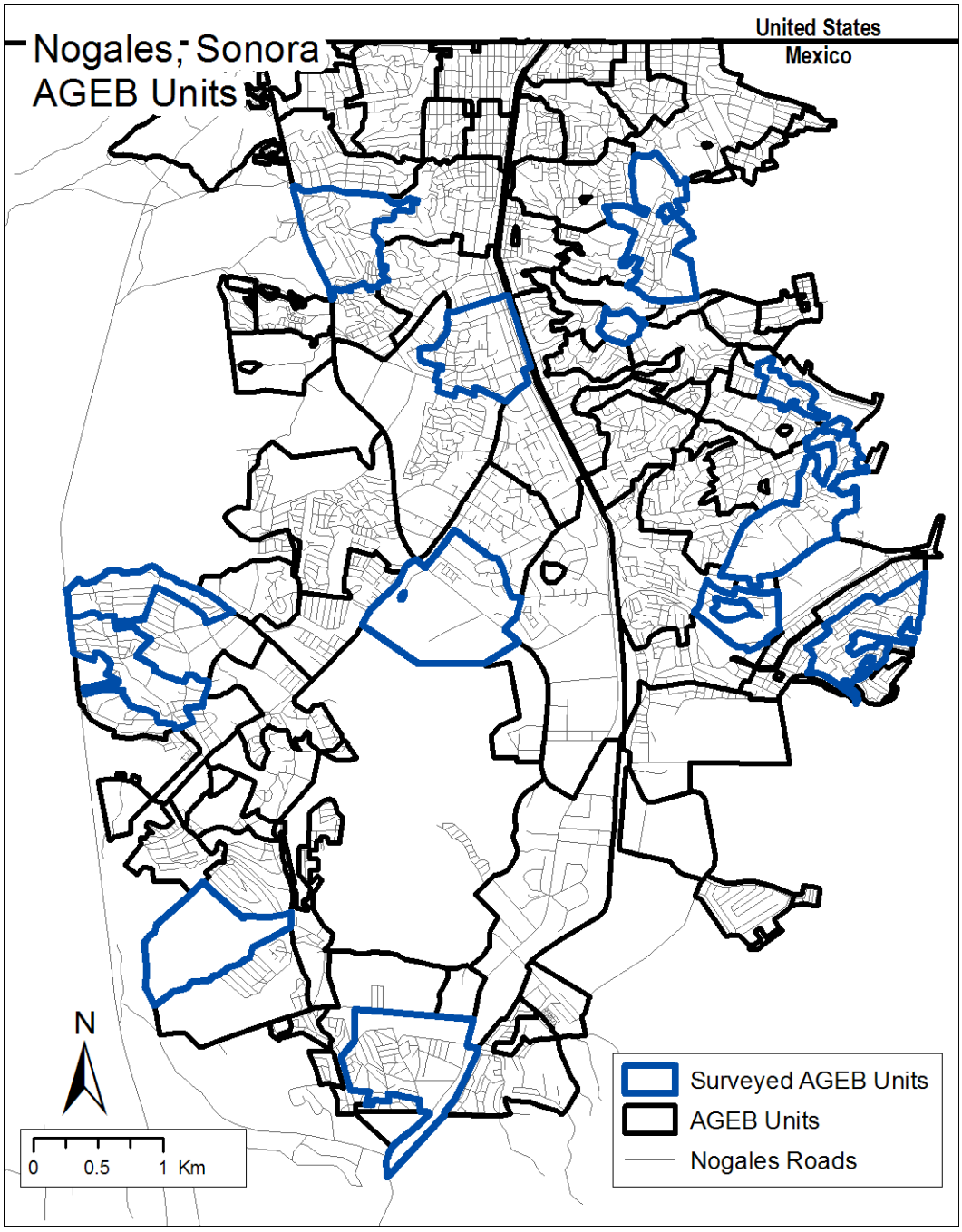

Figure 2.1. AGEB units included in the study

Once the sampling design was approved by the Advisory Board, the research team designed and pilot tested a survey (see Appendix A) to gather data at the household level. The survey included questions on access to garbage services, frequency of garbage services, whether respondents burn garbage or wood and how often, whether anyone on the respondents' street burns garbage or wood and how often. In addition, though the sampling method allowed for the identification of houses in low/mid/high income areas, it did not distinguish low/mid/high income households. Thus, a survey question was included to find out the income level of the specific household to

allow the research team to examine the influence of both neighborhood and household characteristics on burning. Figure 2.2 shows the distribution of individual household incomes within each classification. Based on the results of the pilot, the survey was revised to increase the clarity and flow of the questions.

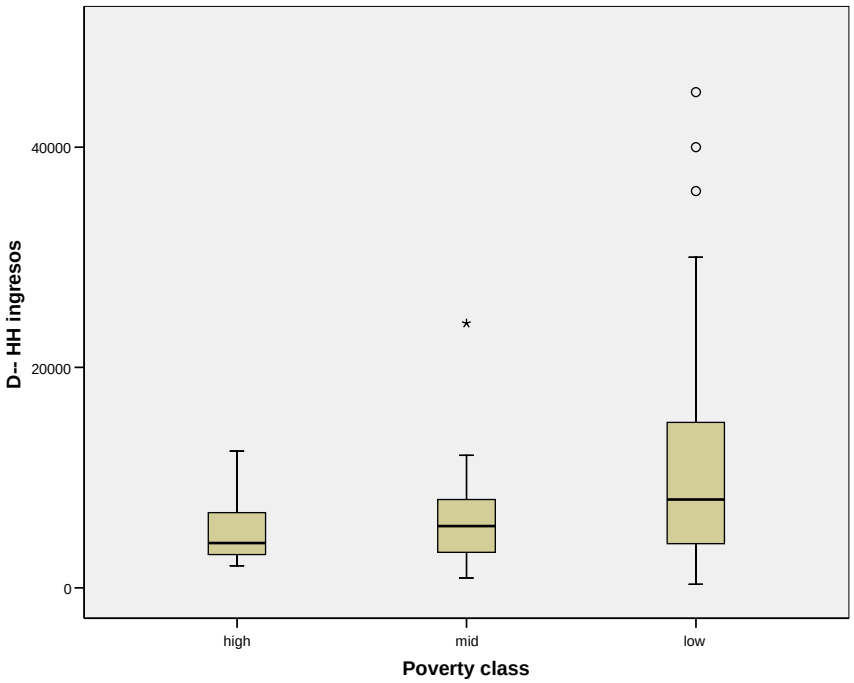

Figure 2.2. Variation in individual household income within each poverty class category

A survey protocol was developed for randomly selecting 12 households within each AGEB unit (with the goal of obtaining usable data on at least 10; see Table 2.1. and Appendix B). The GIS database manager used a random point generator to determine the starting point and direction for the researcher to begin walking within each selected sample AGEB unit, and from those points the researchers proceeded through the neighborhoods. At each selected household, the researchers administered the survey to the adult member who answered the door, or the one called to the door by a child, unless that individual referred the researchers to another adult in the home.

Research team members analyzed and coded the survey responses, and the data were entered into a database created using MS Access and incorporated into the GIS database. The analytical task required comparing burning rates with differences in neighborhood-level factors (such as topography and road quality) and household-level factors (such as income) to identify those having the greatest influence on garbage burning. Interviews, focus groups, and participant observation were then conducted to investigate in greater depth questions that arose from the survey.

Table 2.1. Survey Locations

Classification by Poverty Index	AGEB Units*	Colonias	No. of Households Surveyed
High (> 50%)	028-6 037-5 091-A 099-6	Colosio, Primavera, Jardines de la Montana, Flores Magon, Articulo 27, Diana Laura	46
Mid (25-50%)	036-0 083-5 084-A 116-1	Bella Vista, Buenos Aires, CTS Cecro, Rosarito 2, Solidaridad, Seguro Social	43
Low (<25%)	079-9 126-5 127-A 145-8	Bolivar, Chula Vista, Granja, Kennedy, Lomas de Fatima, Nuevo Nogales, Olivios	47
Total			136

*Note: Throughout the rest of the report the AGEB units are referred to simply as H-1 through H-4, M-1 through M-4, and L-1 through L-4.

It is important to note that while it is possible to utilize adaptive cluster sampling to gather data from a sample and generalize to an entire population, such an approach requires good data on the number of individuals (in this case households) within each sampling unit. Due to concerns about the validity of the 2000 INEGI data by 2006, and especially for the marginal colonias, no attempt was made to quantify the total amount of burning occurring in Nogales.

Restaurant Survey

To get an idea of the nature and extent of wood and garbage burning in small businesses in the city, the research team also designed and conducted a survey of restaurants in Nogales, Sonora (see Appendix C). The team selected restaurants for three reasons: (1) because they cook they would be most likely of any other businesses to burn wood; (2) because they process a lot of material that must go in and out daily, they generate waste that must be disposed of regularly; and (3) because another team of researchers from the Instituto Tecnológico de Nogales (ITN) and UA were conducting surveys of restaurants as part of a study of the potential for biodiesel production and use in Nogales, research team members were able to integrate their survey questions with the other survey and accomplish more than they would have otherwise.

To sample the most restaurants, researchers selected two areas of the city with large numbers of restaurants – the area near the border and the area near the center of the city (see Figure 2.3). The restaurant survey was not intended to quantify the amount of burning occurring within such establishments but instead to triangulate data collected from the other approaches. Survey data was supplemented with information gathered from interviews, focus groups, and participant observation, as described below.

Figure 2.3. Areas where restaurants were surveyed

Questionnaires by ITN Students in their Homes and Workplaces

To supplement the information gathered by the UA research team, a group of ITN students also designed and implemented questionnaires in their neighborhoods and workplaces. They used opportunistic sampling and asked questions about garbage burning and about burning wood for cooking and heating.

Interviews and Focus Groups

UA researchers conducted interviews and focus groups throughout Nogales, concentrating on the colonias where burning was reported to be occurring. The purpose of the interviews and focus

groups was to gather more comprehensive information about the burning practices of Nogales residents and the policies and programs of the municipal government, private waste collectors and recyclers, and construction specialists. By combining both quantitative and qualitative approaches, and triangulating the data from various sources, the researchers were able to balance the strengths and weaknesses of each approach and achieve a higher degree of reliability and validity. In-depth interviews were conducted with residents, government officials, neighborhood leaders, and scrap dealers. In addition, in-depth interviews of the individuals involved directly or indirectly in recycling were also carried out in the study area. Sample questions are included in Appendix D.

Direct and Participant Observation

Participant observation is a research strategy designed to help researchers achieve a high degree of familiarity with a given group of individuals and their practices through intensive involvement by the researchers with people in their own environments. For this study, UA researchers used direct and participant observation to gather information from meetings of the project Advisory Board, the Ambos Nogales Air Quality Task Force, neighborhood meetings and clean-up campaigns, and the various activities selected for evaluation of the pilot action plan. In addition, the researchers rode along with garbage collectors on their regular routes, and spent time at the municipal transfer station and in the homes of local residents.

Draft Action Plan and Pilot Testing

Development and pilot testing of activities to be included in the draft action plan were an important component of this study. Once the data from the surveys, questionnaires, interviews and focus groups, and direct and participant observation had been gathered and analyzed, the UA research team, in collaboration with the members of the Advisory Board, developed a pilot action plan. They then selected seven items to develop and test during the late spring and summer of 2007. As noted above, the researchers participated in the development of several of these activities and utilized their findings to improve the plan.

Final Action Plan

The results of the pilot testing of the draft action plan were analyzed, and the findings were presented at a joint meeting of the Ambos Nogales Air Quality Task Force and the Children's Environmental Health Task Forces. The plan, along with the potential for each action to replace wood burning in Nogales and information about individuals or groups who can play a role in implementing each action, is presented in Chapter Six.

Chapter Three: Nogales, Sonora: History, Development, and Infrastructure

This chapter focuses specifically on Nogales, Sonora in order to provide a backdrop for the research findings, as well as to explain some of the variables affecting the design and outcomes of the study and the development of the action plan. Understanding the historic and current context in which the study of small scale burning took place is also necessary for effectively evaluating proposed action plan elements. Pertinent issues include demographics and population, processes of urbanization, background on waste production, collection and disposal, and local political dynamics.

History and Population Demographics

Nogales is located in the state of Sonora in the northwestern part of Mexico. Its history dates to 1880 when the administration of President Porfiero Díaz opened a customs office at the site of the present city (Salas 2001). Then, in November 1882, the railroad connecting Guaymas to the U.S.-Mexico border was completed. The railroad has remained a major factor in Nogales' development. It passes through the center of the city amidst the hilly landscape that is now covered with informal housing and small businesses.

Nogales, Sonora was officially founded on July 9, 1884 (Nogales, Sonora nd). Commerce has been important to Nogales since its beginning, and the city retains its industrial identity today (see Mendoza 1999). Industrialization has been both a blessing and a curse for the city. The city's prosperity has been accompanied by rapid population growth that has, by and large, proceeded with limited planning. The municipio of Nogales is comprised of more than 160 colonias[2]. Some of the colonias were present when Nogales was founded, but many have been established in recent years.

Downtown Nogales is located close to the international border, and the colonias generally decrease in age with increasing distance from the downtown area (Figure 3.1). Because the downtown area was the first to be founded, it receives services such as sewage and water. The city has expanded southward, to the west, and to the east though steep topography on the eastern edge of town has limited expansion there. In addition, there has been a continual expansion up the hillsides, and elevation correlates to age and lack of services due to the logistical difficulties related to providing infrastructure on steep slopes and at higher elevations.

The expansion of the urban area has been accompanied by a very significant increase in population. According to official statistics collected by the Instituto Nacional de Estadísticas, Geografía Informática (INEGI), the city grew by 50 percent from 1990 to 2000 when the official population of the city was 159, 103. The most recent statistics from 2005 estimate a population of 193,517 (out of a total Sonoran population of 2,394,861), indicating that the population growth shows no signs of abating.

[2] Neighborhoods delineated

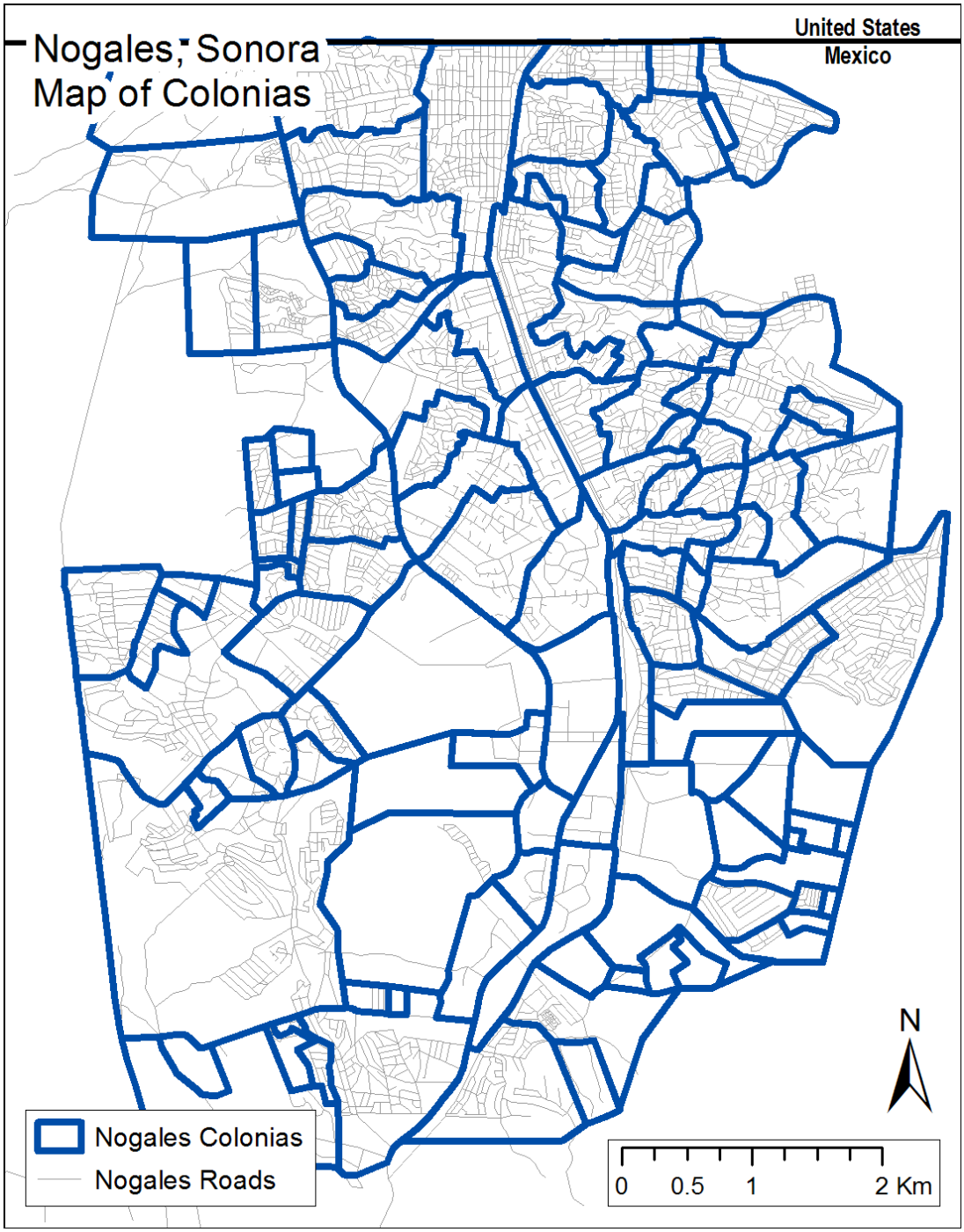

Figure 3.1. Map of Nogales, Sonora

Though there is no argument that Nogales has grown rapidly, the absolute numbers given in the official statistics are generally rejected; scholars estimate the population to be around 300,000 to 350,000 (e.g., Austin et al. 2004; Davidson 2000). The undercount can be attributed to the presence of a transient population that crosses back and forth across the international border, large numbers of residents from other parts of Mexico who come to Nogales for work, a population attempting to gain entry to the U.S. that may set up semi-permanent residence in

Nogales, and return migrants who are deported to Nogales by U.S. Customs and Border Protection. Moreover, the lack of accurate, up-to-date, and detailed maps makes meticulous data collection difficult for census takers. This controversy over population is often a point of contention for local officials who assert that due to underestimates of the city's population they are unable to address the problems exacerbated by the high rates of growth.. Because Federal funding is allocated based on population estimates, undercounting the population means that Nogales, Sonora receives a smaller budget than its population warrants. Furthermore, studies on marginality suggest that the border region is not receiving the benefits that would typically accompany economic growth, suggesting that there is significant resource flight to centralized government agencies (Guillen 2000, Pick and Butler 1990, Peña 2005).

As the first city to start a *maquiladora* industry in the state of Sonora, Nogales has been at the forefront of the state's industrialization. INEGI's Dirección General de Estadística conducts a monthly survey of the Industria Maquiladora de Exportación. As of December 2006, there were 95 maquiladoras operating in the city, employing 32,535 people (INEGI 2006c). Sixty-five of these factories are located within the city's seven industrial parks. Six of the top 50 businesses in the State of Sonora operate within the city. The low-wage employees that work on the assembly line make up the bulk of the workers in the city; workers are often hired on a temporary basis to fulfill seasonal production quotas. The number of factories (Figure 3.2) and the number of employees (Figure 3.3) fluctuate. From 1990 to 2006, there were between 57 and 96 maquiladoras in Nogales with a range of 17,566 to 41,537 employees (INEGI 2006b and 2006c). In addition to its impact on the city's population and economy, the maquiladora industry has numerous effects on Nogales. Of particular relevance for this study is the use and disposal of large quantities of wooden pallets which are used in shipping; the pallets create a major source of fuel to be burned and are also widely used in housing construction. Firewood from trees is much more expensive and therefore has largely been replaced by this cheap waste material. The abundance of scrap wood is an important factor to consider and contributed to the selection of action items (see Chapters Five and Six).

Of other economic activities important to Nogales, the produce industry also warrants mention because of its impact on air quality and the economic activities on both sides of the border. Nogales is the largest entry point for winter produce being transported from Mexico to the United States The produce industry also generates a significant amount of packing material that is disposed within the border communities.

The existence of the industrial sector, as well as the general availability of work in Nogales, spurs much of the population growth and stands out in contrast to the situation in many other parts of Mexico where employment is scarcer. Despite positive economic indicators the uneven process of urbanization in Nogales has meant that many residents' access to infrastructure is comparable to that in more impoverished regions of Mexico (Peña 2005).

Figure 3.2. Number of maquiladoras operating in Nogales, Sonora, 1990-2006. Source: INEGI (2006b). http://dgcnesyp.inegi.gob.mx/cgi-win/bdieintsi.exe

Figure 3.3. Number of people employed in Nogales maquiladoras, 1990-2006. Source: INEGI (2006c). http://dgcnesyp.inegi.gob.mx/cgi-win/bdieintsi.exe

Urbanization in Nogales

The economic draw of Nogales has created a difficult situation whereupon the continued economic growth of the city is limited by its ability to house the workers necessary to operate its factories. Nogales' attraction is heightened by an increasing trend of rural-to-urban migration facilitated by the 1992 amendment to Article 27 of the Mexican constitution allowing for private sale of *ejidal* or communally held land (Azuela and Ward 1994). While an adequate supply of labor exists in Nogales, an adequate provision of housing in the formal sector does not. Growth in formal housing occurs largely through the government-funded INFONAVIT program. This program provides subsidized loans to workers in the formal sector who pay into the program through their social security (see www.infonavit.gob.mx). The housing loans are generally used to purchase housing within *fraccionamientos* (urban subdivisions) or any established neighborhood. The housing units available to workers within the fraccionamientos are often small, two story dwellings, which share at least one wall with a neighboring house and have very small yards and little parking. For example, in Fraccionamiento las Bellotas, which was under construction in Nogales in 2006, two-story houses of 102 square meters was selling for $170,000 pesos (roughly $17,000 USD depending on market rate). Though this is a fairly standard dwelling of its type, there is considerable variation in the quality and price of these homes. According to a local professor and long time contractor for the municipal government, generally prices range from $14-20,000.

Despite the recent increase in government-sponsored housing development in Nogales, homes are not being built quickly enough to meet demand and are not available to workers who lack formal employment and do not pay social security or to young workers who have not contributed enough to obtain a favorable loan. When combined with high land prices, due in part to competition from developers who are building the large industrial parks, the result is a large informal housing sector (Peña 2002, 2005).

Nogales' informal housing sector is characterized by squatter settlements with varying levels of organization that occupy vacant land with or without the permission of political figures or the land owners (Ward 1999). There are several ways in which this process occurs. Sometimes, people encroach gradually on vacant land, one by one, expanding the roads as they go. However, most commonly, land invasions occur under the auspices of a leader who has a certain level of political connections often through a union or other organization. The leader will organize groups of people and try to gain backing for the invasion from politicians or local organizations; this backing is then used to negotiate a price for the land from the land owner or, in some cases, a land swap between the government and the landowner (Ward 1999). There is much criticism of this process as many leaders have been accused of corruption, as well as exploiting poor and destitute people. Exploitation and motivation aside, it is clear that this system lends itself to inefficiency and is therefore open to exploitation from any number of parties.

One factor that complicates planning for services and accounting for growth is the lack of certainty in a land invasion. Investments in planning prior to and in the early stages of an invasion are risky and subject to legal prosecution. Residents may be forced to move in the coming days, weeks, months, or years, so they build slowly and cautiously. The roads that emerge during the development of the neighborhood are often difficult for large garbage trucks

to traverse. At the same time, legal battles can last for years, and the government is not permitted to begin projects within the area until all legal issues are resolved. In the meantime, the residents of these informal housing settlements live with little to no services, depending on proximity to existing neighborhoods. When neighborhoods are nearby, neighbors can share electricity via extension cords. Garbage service can also be available to those who are close to main roads and are willing to carry garbage to the nearest pick up point. However, because expansions of urban territory typically occur near neighborhoods that are only a few years ahead in the regularization process, these neighborhoods often do not have consistent access to public services and infrastructure either.

Typically the first service to arrive is electricity (Peña 2005). According to INEGI data from 2000, 94.2 percent of the population of Nogales, Sonora has access to electricity with 89.1 percent of the population with incomes in the lowest quartile receiving electricity formally as compared to 81.1 percent and 65 percent, respectively, with access to sewage and piped water (INEGI 2000 in Peña 2005). The low rate of access to water in Nogales is largely due to topography. Only 52.3 percent of the population in the lowest income quartile has access compared to 78.1 percent of those in the highest income quartile, due primarily to the fact that the most marginalized colonias are located away from the city center and high up on the hillsides (INEGI 2000 in Peña 2005). In the mean time, residents purchase water from trucks called *pipas* and store it in buckets, drums, or water tanks. Garbage collection services are also related to the age and level of development of the colonia. In Nogales Sonora, garbage collection has traditionally been free, but long-established areas receive collection three days a week whereas marginalized areas receive less frequent service. In the following section, a discussion of garbage collection in Nogales, Sonora provides the context for understanding the nature and extent of garbage burning within the city.

Waste Collection and Management

Municipal elections are held in Mexico every three years. The 2006 elections occurred as this study began and resulted in a complete change in leadership within the Nogales municipal government, with the new administration taking office in September. The 2006 election marked the departure of the former ruling Revolutionary Institutional Party (Partido Nacional Revolucionario; PRI), which had maintained a stronghold of support in Nogales despite its loss of national power. The National Action Party (Partido de Acción Nacional; PAN), which at the same time won the national election for the second term in a row, replaced the PRI in Nogales. As a result of the change, city services and programs were undergoing changes throughout the study. Information in this section describes the situation as it existed as of the end of 2006 and beginning of 2007. Recent efforts by the current local administration to effect change in services are described and discussed in Chapters Five and Six.

In Nogales Sonora, in early 2007, the budget for collection of municipal solid waste (MSW) was $90,000,000 pesos (aprx. $9,000,000 USD) and, according to officials, had remained fairly constant for years. Inaccurate census data has affected how much money is allocated for MSW service. Because official population estimates are low, the Department of Public Services has received insufficient funding to supply service to all of Nogales.

In 2005, there were 5 sanitary landfills in the state of Sonora (INEGI 2006d). Until 1995, MSW was deposited at the Nogales municipal landfill located on the eastern side of the city. Between 1990 and 1995, complaints about the landfill, and particularly fires there, drew official attention to the site. In the years leading up to and immediately following the passage of the North American Free Trade Agreement (NAFTA) in 1994, both U.S. and Mexican citizens and leaders were expressing concern about environmental issues at the border, Negative impacts such as smoke and odor related to burning at the landfill were noticed and reported to officials on both sides of the border. Between April 1994 and August 1995, for example, the Arizona Department of Environmental Quality (ADEQ) responded to 13 incidents at the site (personal communication, ADEQ border air quality staff, 10-1-07). Rising complaints from Arizona residents and leaders put pressure on Sonoran officials to take action to improve conditions at the site. Consequently, the landfill was closed in February 1995 and converted to a transfer station. A new landfill was opened south of Nogales with an expected life of about 20 years. Neither the landfill nor transfer station are lined to prevent leaching of materials offsite nor outfitted with methane venting tubes.

The transfer station was originally intended to serve as such for five years, but its life has been extended several times; current estimates are that it will remain in operation until 2015. By 2003 and 2004, ADEQ officials noticed that the original landfill site was not being operated solely as a transfer station and specifically that some waste was being landfilled there, raising the potential for burning to occur there. During this study, researchers were told and observed that the transfer station continues to serve as a landfill on occasions when the waste has been compacted but no tractor trailers are present to collect it and take it to the new landfill. When this occurs, the MSW is buried at the site.

On average 200 to 250 tons of garbage pass through the transfer station per day. Figure 3.4 shows monthly totals for 2006, in tons.[3]. A total of 72,239.81 tons of garbage were collected by public services 2006.

Twenty-four people are employed at the transfer station, weighing, organizing, and approving the waste that comes from the municipal trucks as well as from private citizens. The garbage is then compacted and shipped to the municipal landfill south of the city where another four people are employed. During this study, *pepenedores* (pickers) were working at the transfer station to remove any materials that could be sold. A fence and controlled access prevented any pickers from working at the landfill. Though there are fewer pickers than in cities such as Tijuana or Ciudad Juarez, their presence must be accounted for in any efforts to change the management of MSW. In addition, though the practice was not observed directly by the researchers, interviewees reported that the pickers sometimes burn the plastic off of coated wire to get to the valuable copper inside.

[3] The variations in amount of garbage most likely do not reflect true fluctuations in the amount of waste produced in the city but rather a difference in recording or timing of collection.

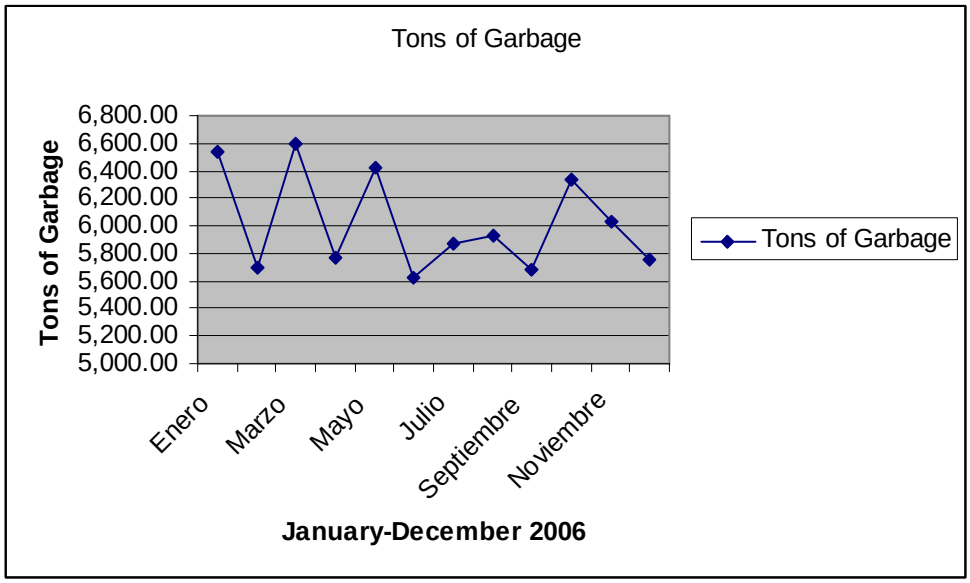

Figure 3.4. Monthly totals at the Transfer Station
Source: Nogales, Sonora Department of Public Services

The other major component of the Nogales MSW management system is collection and transport. In February 2007, approximately 250 people worked driving the trucks and collecting garbage. Twenty-eight routes covered the city and each truck made two to three trips per day. While each colonia is supposed to have MSW pick-up three days per week, most did not, especially those on the outskirts of the city that are not fully regularized. Many colonias on the west side of the city are far from the transfer station and, because of the infrequency of pickup, generate significant amounts of garbage between pickups. As a result, collection along these routes take much longer and often requires more than one trip to the transfer station to complete. Workers are paid by the routes that they complete, not the hours they work, which increases the incentive to work more efficiently but also the desirability of working in the more established colonias.

No waste separation was occurring at the household level, and controls on what could be picked up and taken to the transfer station and landfill were weak. A sign at the city's transfer station stated that the deposit of tires, sawdust, different types of cardboard (yeso and arenado), oils, wood, branches (ramas), couches, mattresses and other junk (chatarra) is prohibited, but often such items are mixed in with other waste. In general, garbage collectors would not pick up large items such as branches and furniture, but residents sometimes paid them extra to take items they would not otherwise collect. For example, researchers observed a collector ask the driver if he should take the large palm fronds and a patio umbrella sitting by the side of the road. The driver said no, so the large items were left. As the truck was pulling away from the house, a woman walked out and offered the collectors 100 pesos. The driver nodded and the workers heaved the branches and the umbrella up into the truck.

Though not part of an official program, in addition to the separation done at the transfer station by the pickers, informal recycling was occurring at the point of collection, performed by garbage

collectors who would separate valuable items such as metal cans and electronics from the waste. However, the ability of garbage collectors to separate valuable items from the garbage was dependent upon which type of truck was being used. Teams of workers are fixed and are assigned to trucks and to routes; the routes are fixed, but the types of trucks to which the teams are assigned can vary.

As of early 2007, three basic classifications of dump trucks were being used by the Department of Public Services to collect residential MSW. The most common trucks are open (Appendix E, Figure E.1, picture of open truck) and require three workers in the back, two outside to collect trash and one inside to lift containers and empty them before throwing the containers back. Depending on their size, the containers are either lifted or emptied into smaller containers that are easier to manage. The worker inside the truck is also in charge of much of the separation of valuables. The collectors use several trash cans located at the head of the truck to store valuable items such as aluminum cans, toys, electronics, or other usable goods. The collectors also use spaces around the truck from which they hang bags that can be filled with cans. Compactor trucks (Appendix E, Figure E.2), on the other hand, make separation more difficult. The third type of truck, a converted pickup truck with a large enclosed bed, was used to access areas difficult for larger vehicles due to the conditions of roads or the topography of the area.

Although the garbage collectors can potentially benefit from separating and saving valuable items, the garbage collectors interviewed for this project said that the added difficulty of collecting trash in an open truck makes working in an open truck less attractive than in the others. Much of the trash is stored in large 55 gallon drums which are very heavy when full. Lifting each drum above one's head to hand it to the worker on top of the truck is tiring work.[4] In contrast, on a compactor truck the collector loads trash into the rear at waist height and the truck compresses garbage inside. Compactor trucks also carry almost twice the load as open trucks, making it easier for the collectors to complete all their routes. At the time of this study, the municipal government had no automated trucks to empty large dumpsters.

A few private companies offer MSW collection service for businesses in Nogales. The largest of these companies is called Promotora Ambiental, known in Nogales as GEN. Promotora Ambiental works in over 30 cities in Mexico, and in about 20 of these cities, the municipal governments have contracted with the company to provide collection service to their residents. Recurring discussions regarding privatization of garbage service for Nogales have occurred, with the latest discussion happening as recently as spring of 2007. The city government has continually rejected proposals to privatize its MSW collection. GEN has also proposed to privatize the municipal landfill, claiming that the municipal government lacks the economic resources to properly control the site. One hundred ninety-six businesses in Nogales contract with GEN, and many of those businesses have multiple locations. GEN currently has 290 containers in Nogales (small, green dumpsters with GEN written on the side in white). The company has two garbage trucks that are able to lift the dumpsters up and empty them into the truck. In all, GEN collects about 700-800 tons of waste per month in Nogales. The items they collect that are recyclable go to the Transformadores de México (see "Recycling" in Chapter

[4] The team of UA researchers accompanied garbage collectors on their work and participated in collection to better understand the obstacles to improving services. Many thanks for their hard work and openness to our amateur participation.

Five). In June 2007, researchers noted smaller trash cans at some of the businesses serviced by GEN, and these had separate sections for organic and inorganic waste.

Politics and Waste Collection

Like other cities in Mexico, Nogales' system for collecting and processing MSW is insufficient (see Chapter One). All officials and workers interviewed for this study agree that the city lacks the trucks necessary for effectively operating routes to serve all the city's neighborhoods. Because of this, political allegiances and patronage systems have played a role in decisions about to whom and where resources have been allocated. Without enough resources to go around, those in power assume the responsibility of allocating the resources that are available.

Due to changes in personnel in the Public Services department, garbage service can vary significantly with changes in the municipal government. As noted earlier, Nogales underwent a significant change in administration, from PRI to PAN, which affected MSW management and therefore this study. It is difficult to evaluate garbage trends over a long period of time. During the first four months of 2007, municipal garbage collection averaged 4,610 metric tons per month, considerably lower than during the same time period (January –April) in 2006 when collection averaged 6,149 metric tons per month. According to city officials, a widespread reduction in garbage collection occurred throughout the city during this period because of the poor condition of the trucks. How, why, and where collection was reduced would require further study. It is not possible to estimate the impacts the change had on the levels of burning occurring at the time this study was conducted.

During this study, Nogales voters passed a referendum to allow the city to assess a monthly fee of 15 pesos per household, to be added to the utility bills, for garbage collection. Until that time, collection had been free. The extra revenue was requested so the municipal government could purchase additional trucks (see Chapter Five). Chapter Five will also address other recent projects to increase cleanliness and improve the condition of many colonias and will discuss the expansion of MSW management services and other projects underway to improve waste collection.

Wood Burning for Cooking and Heating

Relatively little is known about the extent and impact of small-scale wood burning in Nogales, though the practice is known to be common in some neighborhoods and to increase during the winter at the same time that temperature inversions trap air pollutants close to the ground. A 1999 study by researchers at Arizona State University indicated that 23 percent of Nogales, Sonora households burned wood (Sadalla, Swanson, and Velasco 1999). However, because that study was designed simply to document that pollution was being produced by *maquiladora* workers attracted to border communities, investigators did not examine frequency, extent, and seasonality of burning, as well as other factors that could help to reduce the incidence and consequences of small-scale burning.

A 2006 study of alternative stoves revealed that many Nogales, Sonora households maintain a variety of cooking devices (Austin et al. 2006). Many low-income families who have access to

gas or electric stoves and water heaters continue to use a variety of wood-based cooking and heating devices, including open fires, home-made 55-gallon drums with no exhaust mechanisms, and commercial wood stoves vented outside the house (see Appendix F for photos). Families select among these various stoves based on the food that is being cooked, seasonal weather conditions, and fuel price or availability, among other factors. For example, although many homes have access to gas stoves, recent increases in natural gas prices prompted residents to use wood more often as a cooking and heating fuel. Similarly, residents with easy access to the transfer station or informal dumps frequently burn paper, plastic, packing foam, clothing, leather, varnished and painted wood, and other waste products.

Fuel use varies significantly through seasons as well. For families who have adequate resources to consistently purchase gas, use rises over the winter months due to the need to heat water for bathing. Many families who rely on wood as a fuel often decrease the use of gas over the winter because of the double function of wood as a fuel for heating as well as cooking. Still others rely more heavily on wood for cooking during summer months because it can easily be transported out of the house, thereby not heating the interior of the home when cooking. The 2006 study also found that many poor families do not have devices exclusively for home heating. Instead, these families were more likely to use their wood-burning stoves for this purpose during the cold season and to leave the stoves burning for extended periods of time.

Home Construction, Insulation, and Thermal Efficiency

The type and quality of home construction may also contribute to small-scale burning. Indoor heating makes homes more comfortable during the winter season in Ambos Nogales, where elevations can reach 4,000 feet and average low temperatures dip below 40° F six months of the year. Families living in uninsulated houses made from a patchwork of found and purchased materials will experience colder conditions than those constructed of thermally-efficient materials. The latter will require less heating – and therefore less burning – during the winter, the time when temperature inversions contribute to high levels of air pollution across the city. Improving home construction materials could have the added benefit of reducing the frequency of house fires, a common problem in Nogales, Sonora. Other considerations for home construction include security, privacy, affordability, and availability of construction materials and skilled labor.

Summary

Small-scale burning, of garbage, wood, or other materials, must be understood in the context within which it is occurring. In Nogales, Sonora, factors which contribute to burning include inadequate management of MSW and the use of wood and other combustibles as fuel for cooking and heating. The extent to which these factors affect residents' behaviors, as well as other factors that contribute to burning, are examined in Chapter Four.

Chapter Four: Incidence and Distribution of Small Scale Burning in Nogales, Sonora

Garbage Burning

One goal of the study was to investigate the nature and extent of garbage burning occurring in Nogales. Researchers used surveys, interviews, and focus groups with Nogales residents and leaders to learn more about where, when, and why garbage burning was occurring, As shown in the following sections, there is considerable interaction among location of a neighborhood (especially distance from the center of the city), age of the neighborhood, garbage collection, and burning.

Rates and Distribution of Household Garbage Burning

Data from the survey of 136 Nogales households reveal that household-level garbage burning is occurring in Nogales, Sonora. Though the survey was not conducted to generate estimates of the total number of households that are burning (see Chapter Two), the data help explain the garbage and wood burning that is occurring within the city. In Nogales, 33% of the 136 households surveyed reported burning their garbage, and 29% of those households reported burning at least once a month. When people were asked whether their neighbors burned garbage, the numbers were even higher; 56% of 136 people surveyed reported that people on their street burn garbage at least once a month.

Because a central goal of this study is to understand where and why burning is occurring, in order to design and implement an action plan to reduce burning, data were collected about household-level variables such as income as well as access to and frequency of garbage services (see Appendix A for the survey). In addition to household-level data on income, researchers used INEGI's (Instituto Nacional de Estadística, Geografía e Informática) poverty index, which is constructed at the neighborhood level from a weighted average of illiteracy, primary occupation, water scarcity, plumbing scarcity, electricity scarcity, earth floor, and crowding (Pick and Rebeil 2003). Household-level garbage burning was examined in relation to the poverty index of the AGEB, a basic areal unit created by INEGI that ranges in size from 25 to 50 blocks and includes around 2,500 inhabitants. As shown in Table 4.1 and Figure 4.1, households from high-poverty AGEB units reported burning garbage more often than households from mid- and low-poverty units. Burning garbage among households in low-poverty AGEB units was reported by only 2 of the 47 households surveyed. While these responses indicate trends among AGEB units (see Figure 4.2), it is important to note that there is significant variation at the household level within each unit.

The data on burning level (low, medium, high) was converted to a numerical value for the purpose of aggregating these data within colonias for visual representation. Subsequent checking by calculating the median and modal value for each colonia produces similar visual results.

Table 4.1. Households Reporting Garbage Burning, According to AGEB Unit and Poverty Index, that Reported Burning in Response to the Survey Question: “Do you sometimes have to burn garbage?”

Poverty Index	AGEB Unit	Households Reporting Garbage Burning		
		#	Sample	%
High	H1	10	12	83
	H2	9	12	75
	H3	5	12	41
	H4	5	10	50
	Total	**29**	**46**	**63**
Mid	M1	0	11	0
	M2	3	12	25
	M3	8	10	80
	M4	3	10	30
	Total	**14**	**43**	**33**
Low	L1	1	12	8
	L2	0	13	0
	L3	1	12	8
	L4	0	10	0
	Total	**2**	**47**	**4**

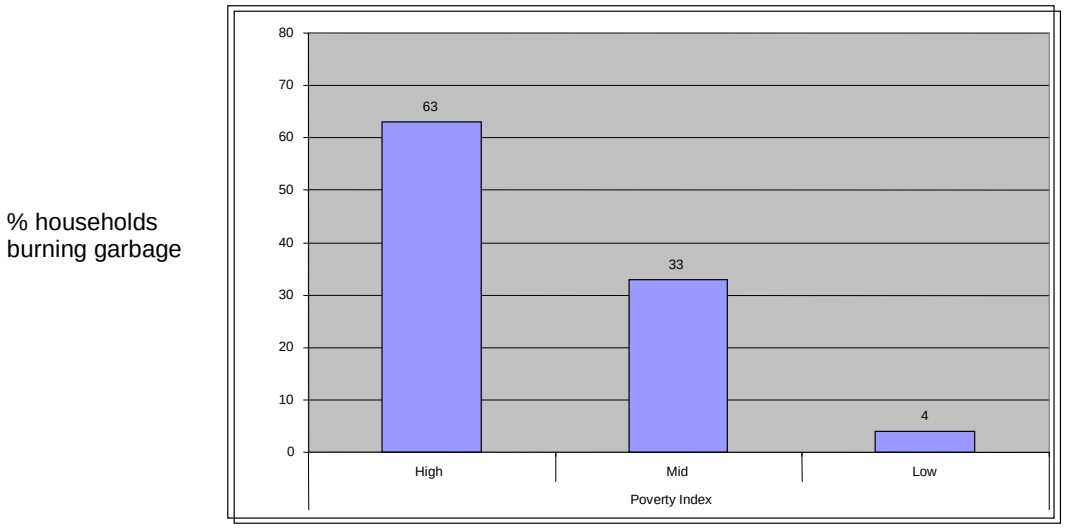

Figure 4.1. Percent of households that reported burning garbage in each poverty index

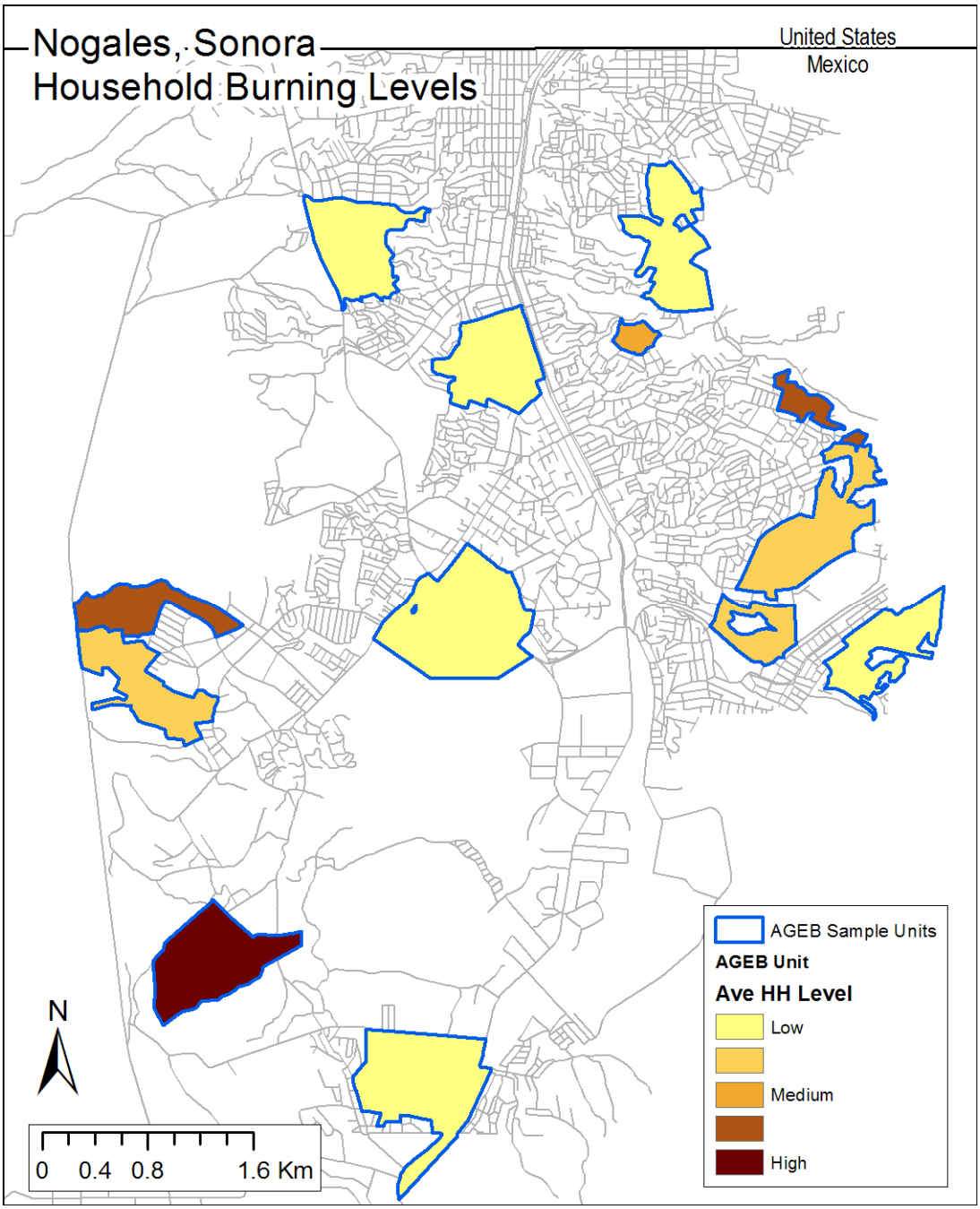

Figure 4.2. Map showing garbage burning according to AGEB units

As shown in Table 4.2 and Figure 4.3, frequency of household garbage burning is also related to poverty index within the AGEB units. None of the residents surveyed in low-poverty neighborhoods reported burning more than once per month. In comparison, 39% of the respondents from mid-poverty neighborhoods reported burning once per month or more and 61% of residents surveyed in high-poverty neighborhoods reported burning once per month or more. Most (85%) of the people who reported burning once per week or more live in high-poverty

neighborhoods. No one in the low-poverty neighborhoods, and only two people in the mid-poverty neighborhoods, reported weekly burning.

Table 4.2. Frequency of Garbage Burning, According to AGEB Unit and Poverty Index, that Reported Burning in Response to the Survey Question: "How often do you burn garbage?"

Poverty Index	AGEB Unit	Frequency of Household Garbage Burning			
		High (Weekly or more often)	**Mid** (At least monthly less than weekly)	**Low** (Less than monthly)	**Never**
High	H1	6	4	0	2
	H2	4	5	0	3
	H3	0	4	1	7
	H4	1	4	0	5
	Total	**11**	**17**	**1**	**17**
Mid	M1	0	0	0	11
	M2	0	3	0	9
	M3	2	6	0	2
	M4	0	1	2	7
	Total	**2**	**10**	**2**	**29**
Low	L1	0	0	1	11
	L2	0	0	0	13
	L3	0	0	1	11
	L4	0	0	0	10
	Total	**0**	**0**	**2**	**45**

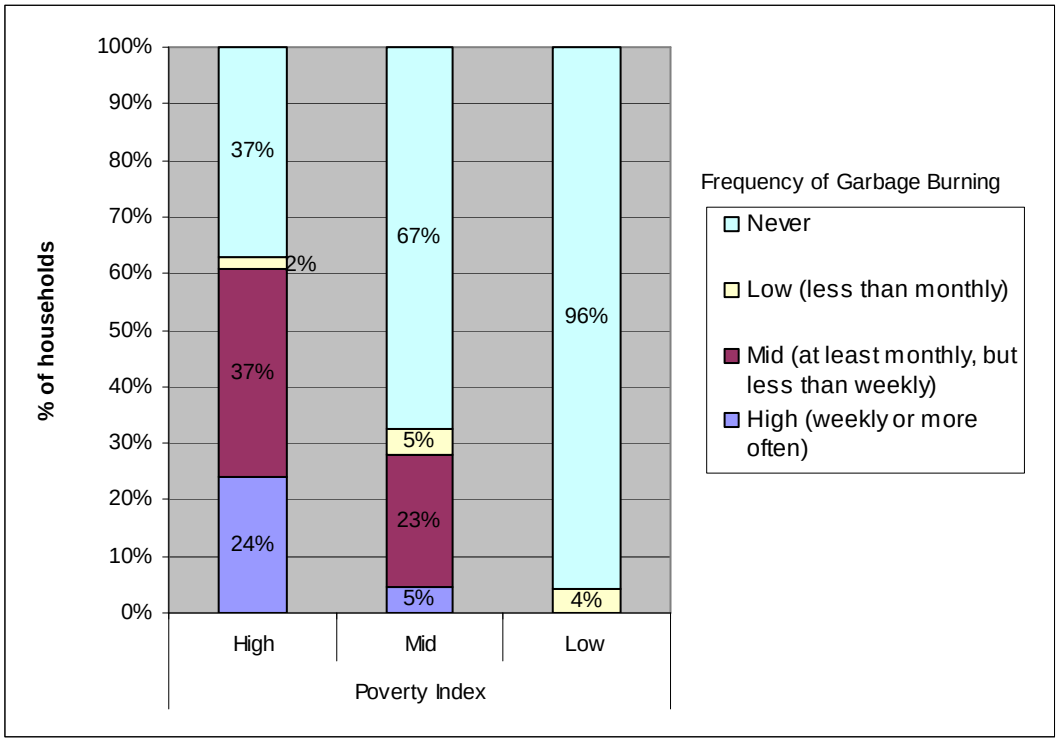

Figure 4.3. Reported frequency of garbage burning in each poverty index

Reasons for Garbage Burning

While elevated incidence and frequency of burning occurs in high-poverty areas, it is important to examine more carefully the specific reasons for this trend, and to explain variations within poverty levels, AGEB units, and neighborhoods. When discussing reasons for garbage burning in surveys, interviews, and focus groups, respondents most often brought up characteristics of garbage collection services (including access to service, frequency of collection, type of container used, distance from the house or business to the collection point), neighborhood characteristics (quality of roads, newness of the neighborhood, topography), or individual household characteristics (including household income, time of residence in Nogales and the neighborhood, number of household members employed).

In interviews, surveys, and focus groups, people throughout the city linked burning of garbage with problems in the collection of garbage. Though more common in the mid-and high- poverty areas, people in all areas of all three classifications told of multiple-week lapses in service, citing these lapses as a reason for burning. Persistent irregularity and complete lack of service were also identified as reasons for burning garbage.

Obstacles to Garbage Collection

Garbage collection in Nogales is limited to what the collectors can easily put into the garbage trucks. Oversized and heavy items, such as furniture, mattresses, rocks, and wood are generally not collected, nor are brush and branches. In surveys, interviews, and focus groups, some individuals noted that they burn these items, citing lack of collection.

Even when a neighborhood has garbage collection, some roads within it may lack service. Individuals interviewed and surveyed often noted that there was collection in their neighborhood, but not on their street. Thus, they would have to take their garbage to the nearest street with service as the collection was occurring. In order to bring their trash to the collectors, the individuals would have to be home and able to carry it to where it could be collected. The individuals interviewed often cited this distance and inconvenience as a reason that they burn their garbage.

During interviews and in surveys, respondents noted the difficulties of storing garbage, citing problems with animals and insects. Dogs getting into garbage and spreading it around was the most commonly cited problem. Even in neighborhoods with regular collection, if the garbage is put out on days the trucks do not come, problems result. As one retired man from a low-poverty neighborhood with regular garbage collection said, “One day [the trucks] come, another day they don’t come, and sometimes the dogs spread trash all over the street.” [“un día vienen [los camiones], otro día no vienen y a veces los perros tiran la basura a la calle."] In several areas, people noted that they burned to prevent problems that arise when dogs get into the trash. Also, in one neighborhood, individuals noted problems with cows going through the garbage. Flies and insects were also a concern of people surveyed. One woman noted that it was better to burn the trash than to put up with the odor and flies.

Garbage Service Regularity as an Explanation for Garbage Burning

What is Garbage Service Regularity?

Survey and interview data suggest that the regularity of garbage collection service is central to understanding garbage burning. Researchers created a new variable to represent garbage service regularity by combining responses to the following survey questions (See Appendix A),

- Does the household have access to garbage collection service?
- Does the household use garbage collection service?
- How often are the garbage trucks supposed to collect the household's garbage?
- How often do the garbage trucks actually collect the household's garbage?
- When was the last time that the household's garbage was collected?
- Does the household experience periods of time without garbage collection?
- Other comments from respondents.

Two researchers reviewed the responses to these questions and classified each household as having regular garbage service, irregular garbage service, or no service. They then compared their classifications and resolved disagreements or uncertain cases by jointly reviewing the surveys.

Is Garbage Service Regularity Based on Neighborhood Poverty Level?

Neighborhood poverty level was found to relate to garbage burning, so the data were analyzed to examine if and how garbage service regularity and poverty status are related. Table 4.3 and Figure 4.4 show the relationship between these two variables. Virtually all (96%) of people living in low-poverty neighborhoods reported regular garbage collection, while only 60% of people living in mid-poverty areas and 19.6% of people living in high-poverty neighborhoods reported regular garbage collection. All of the 14 households surveyed who reported having no garbage collection service were in high-poverty neighborhoods. Half of those without access to garbage collection services live in the same AGEB unit (H1); the other half come from H4 (4 households) and H2 (3 households).

It is also notable that, in one of the high-poverty neighborhoods, every household reported having at least some service. Clearly, provision of collection service is not only a factor of the poverty level of the AGEB unit. Public Works employees noted that their ability to provide regular service depended on several factors, including the topography of the neighborhood, the presence or absence of vehicles and other obstacles in the streets, and the difference in time required to travel on paved versus unpaved roads.

Table 4.3. Relationship between Poverty Index and Garbage Service Regularity

		Poverty Index			
		High	Mid	Low	Total
Garbage	Regular	9	24	45	78
Service	Irregular	23	16	2	41
Quality	No Service	14	0	0	14
	Total	46	40	47	133

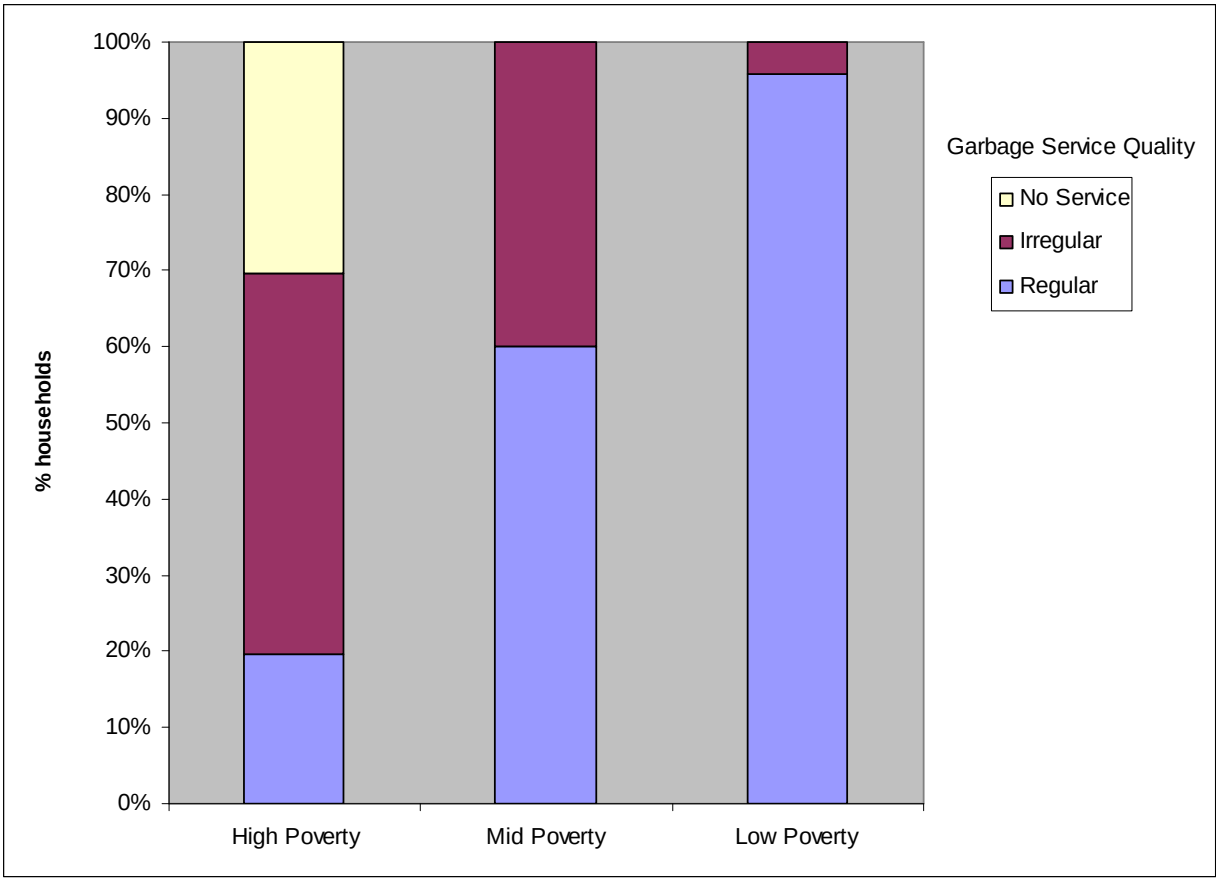

Figure 4.4. Regularity of garbage service collection in each poverty class.

The Effects of Garbage Service Quality on Household Burning

Figure 4.5 illustrates the strong relationship between garbage service regularity and household-level garbage burning. When the data are combined across AGEB units, 76% of households that report that they do not burn garbage have regular garbage service, whereas only 23% of households that report they do burn garbage have regular service. A chi-square contingency test of garbage service quality and garbage burning confirms that there is a statistically significant relationship between garbage collection service and household-level garbage burning ($p<.001$). Households without access to regular garbage service are significantly more likely to burn garbage than those that have access to regular garbage collection.

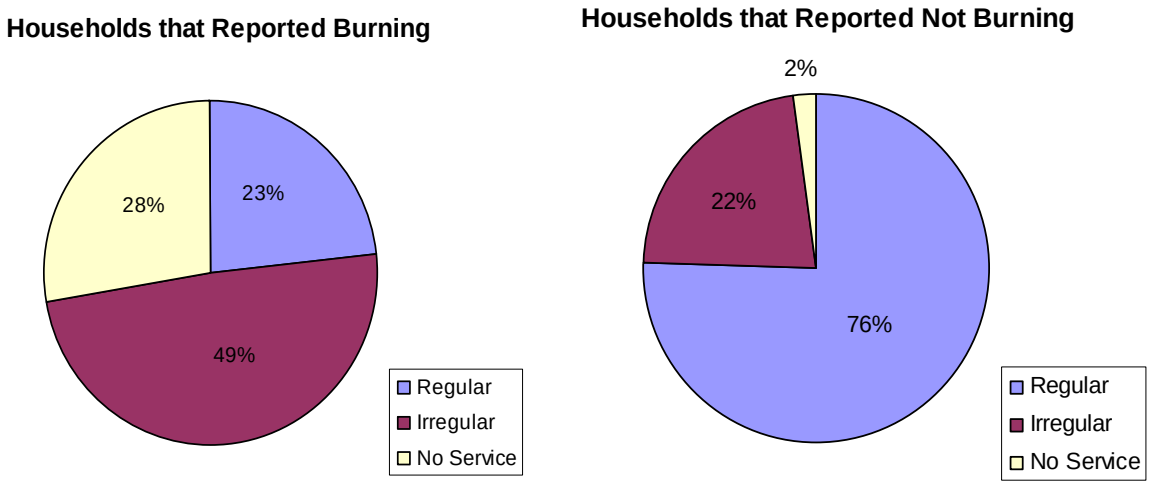

Figure 4.5. Comparison of quality and dependability of garbage collection service for people who reported burning garbage and people who reported not burning garbage.

It is important to note, however, that 23% of the people who burn have regular service and 24% of the people who do not burn have irregular or no service. The activities of these people provide insight into other factors that affect burning and possible action items to reduce garbage burning in addition to improving collection service. Survey respondents who burned their garbage despite having access to regular collection cited the presence of flies, a lack of garbage bags, the amount of garbage, laziness, and the desire to keep the yard clean as reasons for burning garbage. Also, people who have irregular or no service and do not report burning reported other means of disposing of their trash such as putting it in a neighbor's trash can or driving it somewhere to dump.

The effects of garbage service regularity on frequency of burning

Comparing the frequency of burning with the regularity of collection service produces a similar result. Households without regular garbage collection tend to burn much more frequently than households with regular garbage collection. High frequency burners are burning at least once a week. Mid frequency burners are burning less than once a week but at least once a month, and low burners burn less than once a month. As shown in Table 4.4, 93% of high-frequency burners have no garbage collection service or irregular service, compared with 76% of mid-frequency burners and only 40% of low-frequency burners. It is notable, however, that 18.4% (7 out of 38) of the mid-frequency and high-frequency burners have regular garbage collection service.

The respondents who reported burning once or twice a month even though they had regular services gave different reasons for burning. Several noted that service had improved recently and that they had burned previously in response to having irregular service. Others noted that they burned brush, an item that the municipal collection service does not accept. Still others reported that the collection point was located 20 to 40 meters from their house, and that the distance was sometimes problematic.

Table 4.4. Relationship between Frequency of Burning and Garbage Service Regularity

		Garbage Collection Service		
		Regular	Irregular	No Service
Frequency of Burning	High	8 %	31 %	62 %
	(N=13)	(1)	(4)	(8)
	Mid	24 %	60 %	16 %
	(N=25)	(6)	(15)	(4)
	Low	60 %	40 %	0 %
	(N=5)	(3)	(2)	(0)

Reported Reasons for Garbage Burning

The survey included questions that would elicit other possible explanations for household-level garbage burning, including features of garbage collection (the need to be present for collection, distance to the point of collection, types of garbage containers the household uses, and amount of garbage produced) and household characteristics (amount of time living in Nogales, amount of time living in that colonia, household size). Because of the strong influence of the regularity of garbage service on garbage burning, however, it is difficult to determine from the survey data how strongly these factors may influence garbage burning.

The survey asked residents for their explanations of garbage burning throughout the city. Table 4.5 shows responses to the questions "Why do you think that people burn garbage?" and "Are there other benefits to burning garbage?" as well as other relevant comments from surveyed households. Two researchers reviewed the responses to these questions and developed the categories shown in the table. They then compared their classifications and resolved disagreements or uncertain cases by jointly reviewing the surveys. Multiple answers to the questions were allowed, and therefore the percentages below add up to more than one hundred.

The categories included a range of responses which are described below:

- *Service Problems*: Trucks don't come, come late, are inconsistent, or don't collect trash. (No vienen los carros; tardan; El camión no es constante; No recogen la basura.)
- *Quantity*: There is a lot of trash and people burn to get rid of it and so it doesn't increase. (Hay mucha basura; deshacerse de la basura; no aguantan la basura; la cantidad)
- *Animals*: Mentions of dogs, flies and insects. (Evitar los perros; muchas moscas; insectos)
- *Cleanliness*: It looks or smells bad and people burn to clean it up. (Se ve mal; feo; apesta; olor; limpiar el lote)
- *Contamination*: Trash contaminates and causes illness. (La basura puede contaminar; enfermedades)
- *Cultural/Personal*: People burn because they are ignorant, dirty, lazy, or because it is their custom. (Ignorante; costumbre; gente sucia; cochinero; flojo)
- *Fuel*: People burn garbage to heat water or save gas. (calendar agua o salve el gas)

Table 4.5. Reported Reasons for Burning Garbage

	Service Problems	Quantity	Animals	Clean	Contamination	Cultural/ Personal	Fuel
Persons in All (N=136)	**74%** 100	**26%** 36	**14%** 19	**9%** 12	**3%** 4	**10%** 13	**1%** 2
Person who Burn (N=45)	**89%** 40	**29%** 13	**24%** 11	**18%** 8	**0%** 0	**4%** 2	**2%** 1
Personas who do not Burn (N=91)	**66%** 60	**25%** 23	**9%** 8	**4%** 4	**4%** 4	**12%** 11	**1%** 1

In both households that burn and do not burn garbage, collection is noted as the most important factor influencing the burning of garbage. However, individuals who burn their garbage more often cited garbage collection as a factor contributing to garbage burning than did those individuals who do not burn. Individuals who burn their garbage also emphasized the need to keep the area clean, healthy, and free of insects and animal disturbances. Individuals who do not burn their garbage emphasized burning as a problem of culture or lack of knowledge among people who do burn, though some recognized that the practices of those without service were not much different from those with service. One man with good services noted, “Here there is no problem with collection . . . We lack the culture of bagging it well, because of this the air and the dogs take it . . . but the city is satisfying their responsibilities. [Aquí no hay un problema con recolección… Nos falta una cultura de embolsarla bien; por eso el aire y los perros la remueve… pero el municipio esta cumpliendo bien con sus responsabilidades.”

The qualitative data help to explain how other factors beyond garbage collection service are connected with both the regularity of garbage collection service and the decision to burn garbage. Several of the other commonly-cited reasons for burning become particularly important when garbage collection services are irregular or non-existent. Regular garbage collection services remove waste from people’s living area and thereby reduce waste-related nuisances. When garbage collection services are irregular, however, residents are forced to store garbage at their houses for longer periods of time, changing the nature of waste disposal and increasing the associated nuisances. The amount and type of garbage becomes a more significant factor when families are forced to store their own garbage, as waste containing food or other strong scents attracts dogs and insects. The lack of an effective storage container was also cited as a reason for burning.

Irregular garbage service also increases garbage-related conflict within the community. When garbage trucks come regularly, it is less problematic for people without service to use the garbage containers of people with service. However, when garbage service is irregular, it becomes more important to regulate the amount and type of garbage that is deposited in household garbage containers. As a result, residents in neighborhoods with irregular service are

more likely to complain about others using their containers and even to reject offers from either government or NGOs of containers that might become a place where others deposit their garbage (see Chapter Five).

Types of Garbage Burned

The 45 people who reported burning garbage were asked what types of garbage they burned. The majority of these people reported burning paper and/or cardboard (87%), branches and/or leaves (76%), and plastic (69%). Fewer people reported burning glass (27%). Another 27% of the responses were classified as "other" and included wood, pallets, diapers, cans, and clothes. Responses from interviews and focus groups suggest that items such as glass and metal are more valuable and therefore more likely to be reused or recycled rather than burned.

Food was also rarely reported as a type of garbage that was burned (20%). Many people reported feeding food waste to dogs. There was no distinction in the survey between food scraps (such as banana peels) and leftover food. However, interviews and focus groups suggested that most people do not give vegetable and fruit scraps to dogs.

Management of Garbage in Households without Regular Garbage Collection

Of the 55 respondents with irregular or no service, 34 (61.8%) offered an alternative strategy for disposing of garbage. Of those who reported alternative waste disposal practices, 16 (47%) claimed to take the trash themselves to the official dump or transfer station. While this represented by far the most common answer, the means by which respondents obtained transportation differed. Some people indicated that they worked together with neighbors to obtain a car to use. The second most common response, cited by 7 people (21%), was that uncollected garbage was either taken to a clandestine dump or littered. A number of people responded that they sold, gave, or paid an independent collector to take the garbage from them. Seven people also referred to independent collectors, but only 3 respondents (9%) claimed to pay someone to take it, 3 (9%) said that someone takes their garbage but did not mention whether or not they paid for the service. One individual claimed to sell excess garbage, but only that which was perceived as valuable, such as aluminum. As noted in Chapter Three, alternative collection and informal recycling occurs in Nogales in areas where municipal services are incomplete.

Management of Types of Garbage Not Collected by the City

Survey participants were asked an open-ended question about what types of waste the municipal garbage service does not collect. Their answers fell into six general categories: furniture, metal, dirt, tires, brush, and other; because they could report more than one type of waste, the total number of responses is greater than 136. As shown in Table 4.6, 80 individuals reported that furniture—including mattresses, large appliances, wood, and other pieces of furniture—would not be collected. Metal items such as rebar and scrap metal were reported as not collected by 19 people. Dirt, rocks, and cement were listed by 13 people as not being collected. Twelve people noted that tires are not collected and eleven individuals cited brush—including leaves, branches, and grass—among the items the municipal garbage service would not collect. Twelve people listed other items that would not be collected, among them cardboard (4 people), batteries, dead

animals, and cars. Municipal garbage collectors noted that they do not collect large or heavy items, specifying that do not collect "wood, dirt, and rocks." It was observed that the garbage collectors do collect cardboard, in some cases, use it to reinforce the doors of the garbage trucks. Also, small businesses surveyed in four different colonias reported that cardboard is collected along with their other garbage.

Researchers also observed that garbage collectors take certain larger items, including brush and branches, and household items under some circumstances. On two occasions, interviewers observed residents offering a small donation to the trash collectors to encourage them to take these normally unaccepted items.

Table 4.6. Types of Waste Respondents Report as not Collected by the Municipal Service

Waste Items Not Collected	# Households Reporting Item Not Collected*
Furniture	80
Metal	19
Dirt, rocks, and cement	13
Tires	12
Brush, grass, and leaves	11
Other items	12

*N>136 because each respondent could report more than one item.

In the survey, researchers asked how households dispose of garbage that is not collected by the city; only 100 people responded to the question. Most of the people who reported not having service (70%) did not respond to this question, possibly because they had already informed the researchers what they did with all their household solid waste. Of those who did not respond to this question, a larger percentage (38%) reported burning garbage than did not (14%), so burning is probably underrepresented as a strategy for dealing with uncollected items. As shown in Table 4.7, only 5 people who answered the question reported burning garbage that the city will not collect. The vast majority (87%) of those who responded to the question reported taking the materials to another location. Forty-three of these specifically mentioned taking their waste to the municipal landfill or the transfer station, 6 said that they took their waste to the hills or other locations, and 34 did not specify a site. Eight of the people who reported taking their trash somewhere mentioned that they pay, individually or as a neighborhood, to get a car to take it away. Three people said that they pay the city trash collectors to take certain items. Finally, 13 respondents noted that they rely on other collectors or special garbage collection campaigns. Within this final category, one person explained that "special trucks come once a month to collect these things and take them to the city dump" ["una vez al mes vienen camiones especiales para estas cosas y se las llevan al municipio [basurero]"] A colonia leader and another respondent both said that they call or visit the municipio when these types of garbage accumulate and the government sends a truck quickly and at no cost to the residents.

Table 4.7. Household Management of Types of MSW that are not Collected by the Municipal Service

Management Strategy	# Households
Burn	5
Take garbage to another location	82
Special truck or campaign	13
Municipal landfill or transfer station	42
Hills and other areas	6
Unspecified location	34

Rates and Distribution of Garbage Burning in Restaurants

Forty of the 46 restaurants surveyed responded to the question about the type of garbage service they utilize. Of these, 37 reported using the public municipal service, 1 reported using GEN (a private company) and 2 reported using other private services. Forty-one restaurants provided information about the frequency of collection; 33 reported daily garbage service and 8 said they received at least weekly service. None of the restaurants reported ever burning their garbage. Ten of the restaurants separate their waste; five separate food, five separate cardboard, and five separate glass, though only one reported separating all three. In addition, 3 restaurants reported separating aluminum and 1 plastic.

The restaurants surveyed were concentrated near the border and in the central city. In addition, through participant observation and informal interviews, researchers gathered information from food stands and small grocery stores (*abarrotes*) located in the colonias in which the household surveys were conducted. The proprietors generally reported that their solid waste was collected regularly. Some did report burning garbage, especially cardboard, when it accumulated at their places of business. The observed relationship between garbage collection and service appears to hold for such establishments as well.

Wood Burning

A second goal of this study was to identify the factors related to wood burning in households and small businesses in Nogales. As described in Chapter Two, researchers used surveys, interviews, focus groups, and participant observation to investigate the nature and extent of household and small business level burning in Nogales.

Rates of Wood Burning for Household Heating and Cooking

As shown in Figure 4.6, wood burning is common in both mid-poverty and high-poverty areas. Forty percent of households in mid-poverty areas and 46% of households in high-poverty areas burn wood for cooking, heating, or both (see also Figure 4.7). The use of wood for cooking is most concentrated in the highest poverty areas (Figure 4.8), while the use of wood for household heating occurs with similar frequency in mid- and high- poverty neighborhoods (Figure 4.9).

Follow-up interviews with community residents, store owners, and wood sellers during the coldest part of the year suggested that rates of wood burning for heating may be significantly higher in some colonias than was reflected in the survey. These respondents consistently noted that almost everybody in the high-poverty colonias was heating their homes with wood

calentones, and the wood seller estimated that 75% of households regularly used wood for heating. One woman noted that she had tried buying a small *calentón* but had been unable to find one because they had all been purchased.

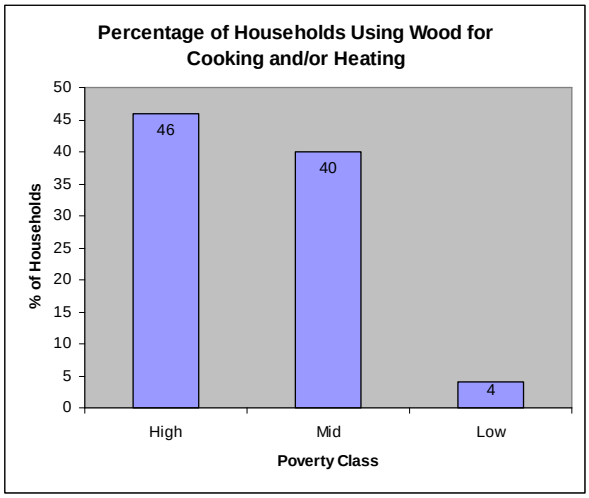

Figure 4.6. Percentage of households using wood for cooking and/or heating, by AGEB poverty index

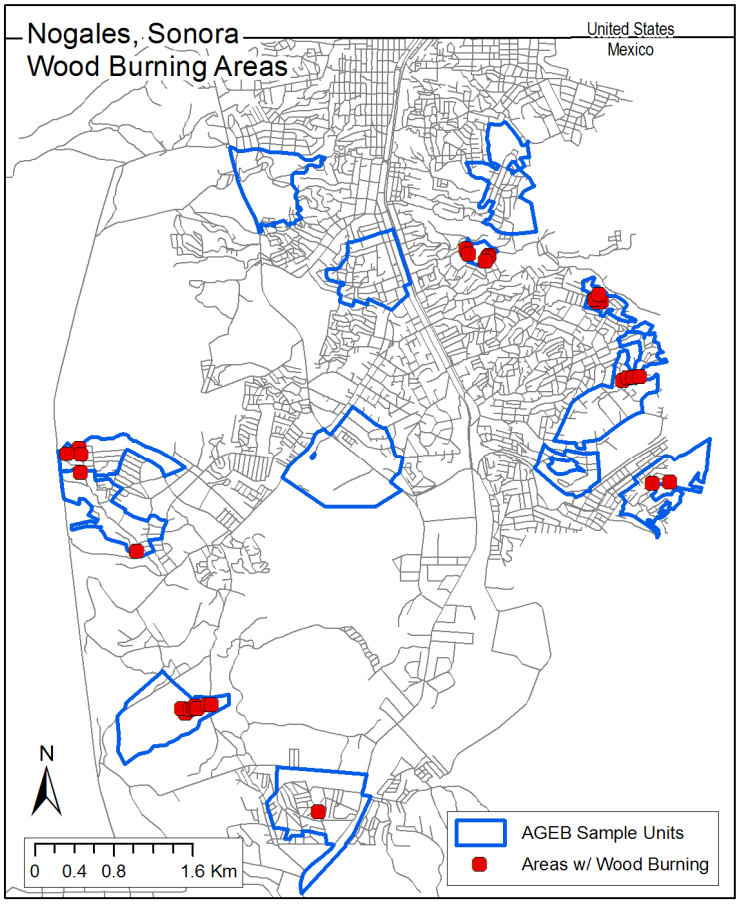

Figure 4.7. Map showing distribution of wood burning

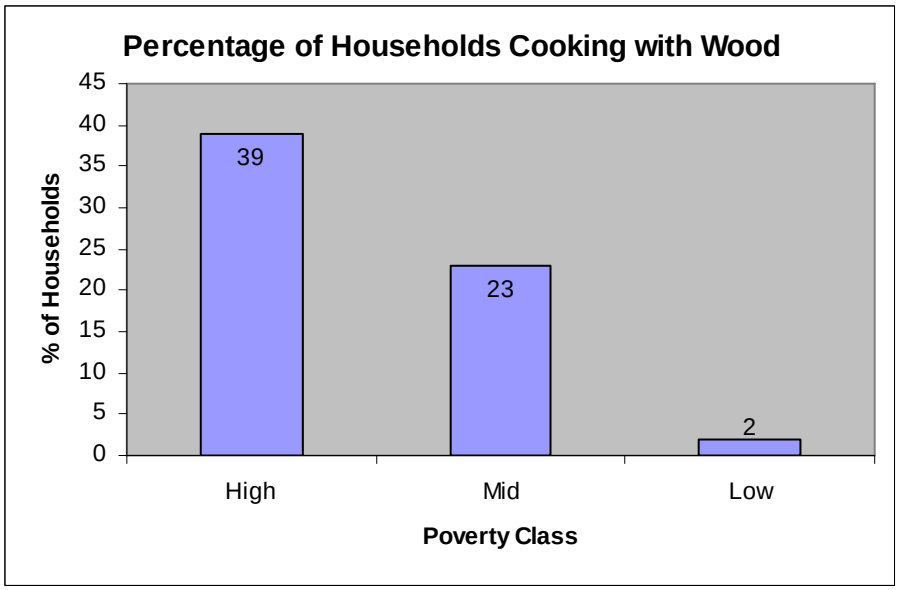

Figure 4.8. Percentage of households cooking with wood, by AGEB poverty index

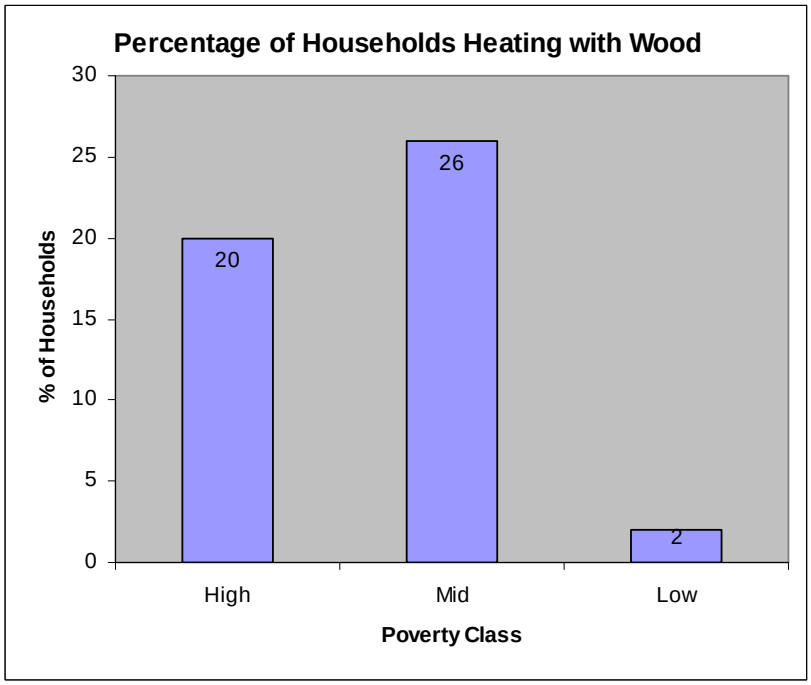

Figure 4.9. Percentage of households heating with wood, by AGEB poverty index

As shown in Table 4.8, however, there is variation in burning levels within the low-poverty class as well as the mid- and high- poverty classes. Therefore it is important to also examine burning levels within as well as between AGEB units. The table below shows the burning levels for cooking and heating for each AGEB unit, and the next section will discuss burning in relation to the incomes reported by individual households on the surveys.

Table 4.8. Rates of Wood Burning in the AGEB Units Surveyed

Poverty Index	AGEB Unit	Households Cooking with Wood (%)	Households Heating with Wood (%)	Households Using Wood for Heating and/or Cooking (%)
High	H1	67	33	67
	H2	33	8	33
	H3	8	17	17
	H4	50	20	70
	Total	**39**	**20**	**46**
Mid	M1	18	27	36
	M2	33	33	50
	M3	40	10	40
	M4	0	30	30
	Total	**23**	**26**	**40**
Low	L1	0	0	0
	L2	8	0	8
	L3	0	0	0
	L4	0	10	10
	Total	**2**	**2**	**4**

Reasons for Wood Burning

Previous research in Nogales has indicated that cost is one of the key considerations for residents selecting heating and cooking fuels (Austin et al. 2006). Non-wood energy sources such as gas and electricity are generally available even in high-poverty neighborhoods, and other neighborhood features such as topography or distance from the city center are not very likely to play a significant role in heating and cooking decisions. The key factor determining whether or not a given household can access these goods therefore appears to be household income or purchasing power.

Household Income as an Explanation for Wood Burning

To examine the effect of household income on wood burning, individual households were assigned to one of three household income classes (the lowest one-third of incomes, the middle one-third, and the highest one-third) based on their reported income. Household income class was then examined in relation to decisions to cook with wood. As shown in Figure 4.10, families who report lower incomes are more likely to use wood as a cooking fuel than those who report higher incomes. The mean household income of families cooking with wood is less than half the mean of families not cooking with wood ($4,259 compared with $8,760), and the medians showed a similar difference ($3,350 vs $6,100) (Table 4.9).

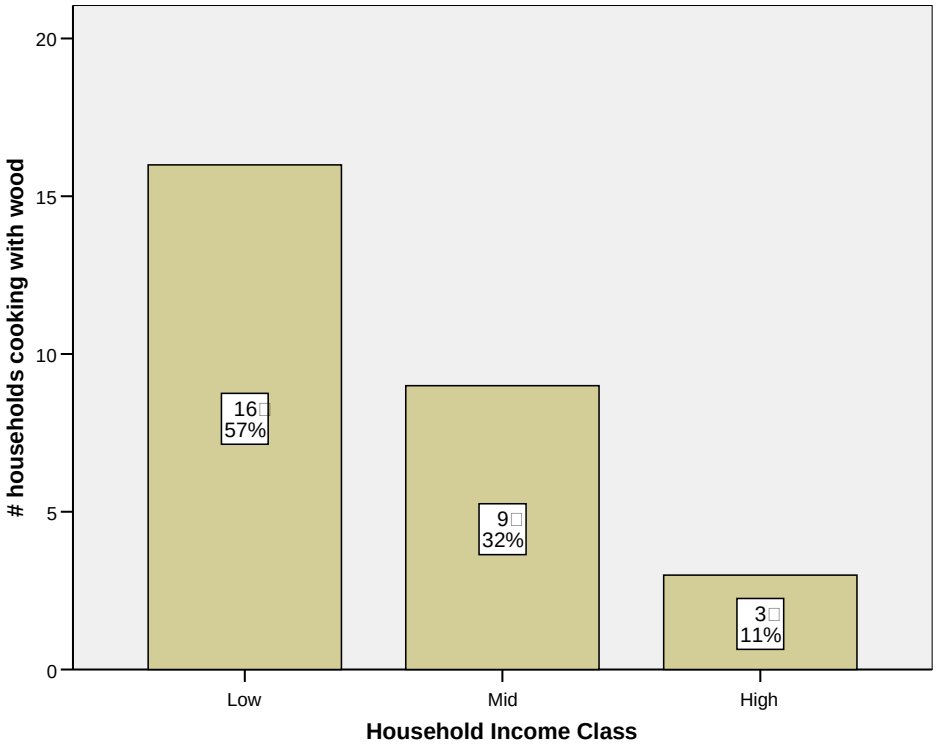

Figure 4.10. Households cooking with wood, by household income class

Table 4.9. Comparison of Household Incomes of those Households who Do and Do Not Cook with Wood

		Households Cooking with Wood	Households Not Cooking with Wood
Income	Mean	$4,259	$8,760
	Median	$3,350	$6,100
	Range	$9,100	$44,700

At first glance, the same trend does not seem to apply for decisions to heat with wood (Figure 4.11). An equal number of low- and middle- income households (7) use wood for heating and a similar number of high-income households (5) also uses wood. However, when the range of heating options is examined in greater detail, it is evident that household heating decisions are affected by household income. As Figure 4.12 and Table 4.10 show, almost half of the households surveyed reported not heating their homes at all. Those families' mean income ($5,946) is lower than the mean income of families who heat with wood ($7,090), which in turn is lower than that of the families who heat with gas or electricity (both over $10,000).

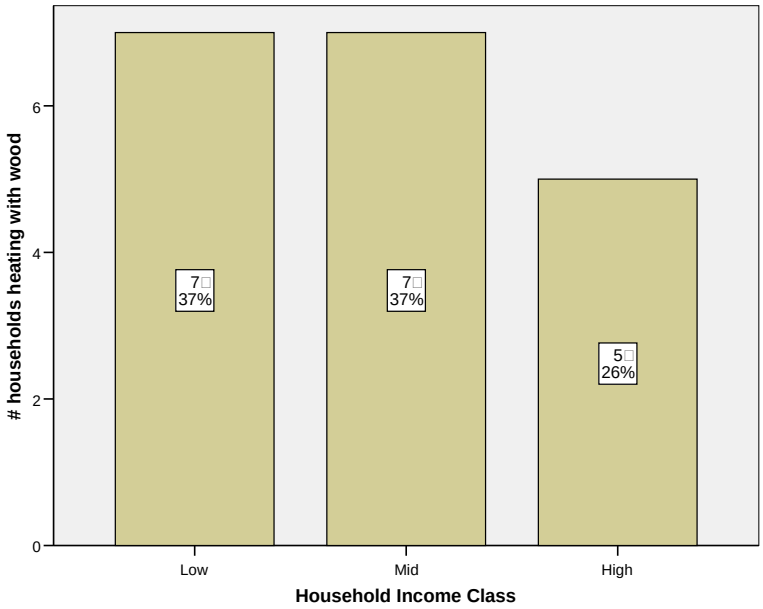

Figure 4.11. Households heating with wood, by household income

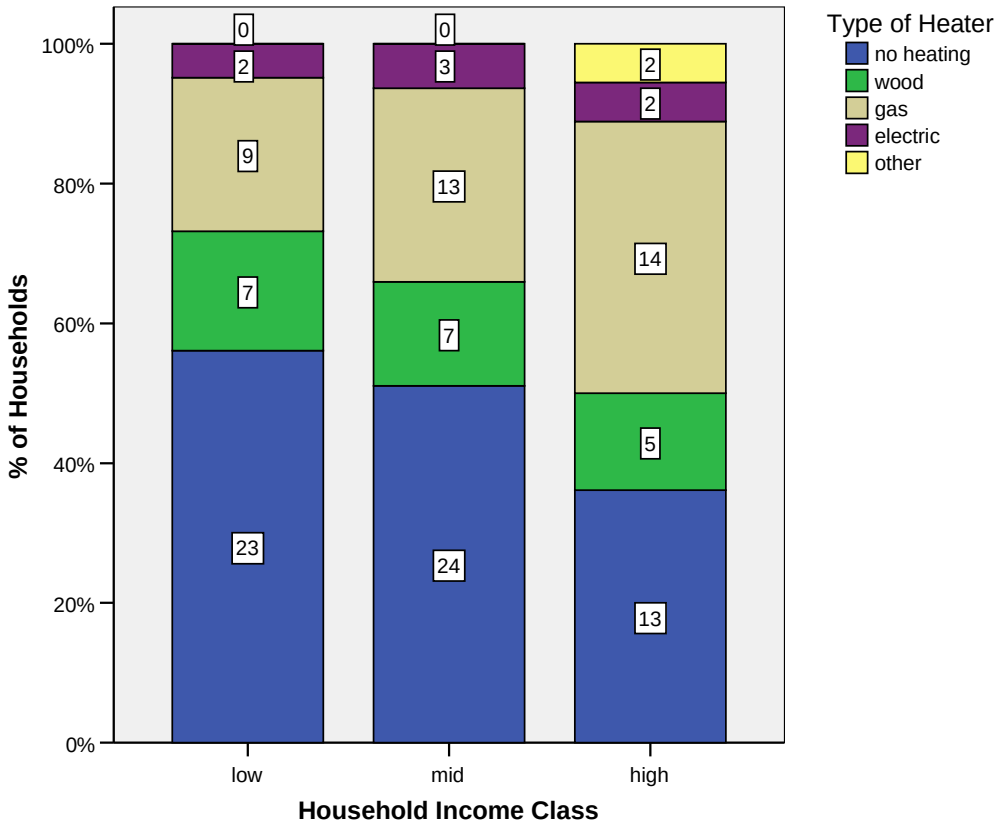

Figure 4.12. Types of household heating, by household income

Table 4.10. Relationship of Household Incomes to Types of Heating

		Heating Type			
		No Heating	Wood	Gas	Electric
Income	N	60	18*	36	7
	Mean	$5,946	$7,090	$10,131	$10,571
	Median	$4,450	$5,000	$6,450	$6,000
	Range	$23,700	$27,200	$44,100	$37,000

* The total number of households heating with wood is 21. These numbers do not include two households that did not report their income and one household that heats with both wood and gas.

Household Income and the Frequency of Wood Burning

Frequency of wood burning is also related to both the poverty index of the AGEB unit and individual household income, as shown in tables 4.11-4.14. However, the data do not reflect seasonal differences. Low percentages of burning within the total sample may be due to the fact that the survey was conducted in the fall, before the weather in Nogales turned particularly cold. Data from interviews, focus groups, and participant observation indicate that the levels of burning increase during the cold winter months.

Table 4.11. Frequency of Wood Burning for Cooking, by Poverty Index within AGEB Unit

		Frequency of Wood Burning for Cooking		
		Once a week or more	Less than Once per week	Total
AGEB Poverty Index	High poverty	12	6	18
	Mid poverty	6	4	10
	Low poverty	1	0	1
	Total	19	10	29
	Percentage of Total Sample	14%	7%	21%

Table 4.12. Frequency of Wood Burning for Cooking, by Household Income

		Frequency of Wood Burning for Cooking		
		Once per week or more	Less than once per week	Total
Household Income	Low Income	11	5	16
	Mid Income	7	2	9
	High Income	1	2	3
	Total	19	9	28*
	Percentage of Total Sample	14%	7%	21%

*Note: One household that reported using wood for heating did not report its household income

Table 4.13. Frequency of Wood Burning for Heating, by Poverty Index within AGEB Unit

		Frequency of Wood Burning for Cooking		
		Once a week or more	Less than Once per week	Total
AGEB Poverty Index	High poverty	9	0	9
	Mid poverty	11	0	11
	Low poverty	1	0	1
	Total	21	0	21
	Percentage of Total Sample	15%	0%	15%

Table 4.14. Frequency of Wood Burning for Heating, by Household Income

		Frequency of Wood Burning for Cooking		
		Once per week or more	Less than once per week	Total
Household Income	Low Income	7	0	7
	Mid Income	7	0	7
	High Income	5	0	5
	Total	19	0	19*
	Percentage of Total Sample	14%	0%	19%

*Note: Two households that reported using wood for heating did not report their household income

Reasons for Wood Burning

Only fourteen survey respondents specifically discussed reasons for wood burning. Among those who did respond, the most common explanation for wood burning (cited by four people) was the high cost of gas, gas stoves, and heaters. Other respondents discussed the seasonality of wood burning and the need to stay warm (4), the burning of wood for special occasions such as *asados* (2), and the lack of reliable electricity for electric stoves or heaters (1). Two people expressed concerns about home fires and one noted that the best way to solve the wood burning problem was to educate people more about the health consequences of burning wood. In focus groups and a questionnaire implemented by students from the Instituto Tecnológico de Nogales (ITN), respondents noted that they cook with wood because it is cheaper than gas, and that they also burn wood seasonally for heat.

Previous research on cooking and heating in two high-poverty areas in Nogales revealed that many households maintain a variety of stoves so that they can remain flexible to changes in fuel price and availability, seasonal heating needs, and different cooking needs (Austin et al. 2006). Key criteria residents consider when selecting stoves include price, safety, fuel cost and availability, ease of use, versatility of stove, aesthetics, size, and permanence/portability. Focus groups, individual interviews, and workshops conducted during the previous study resulted in the following key findings, which are relevant to the development of an action plan for reducing burning:

- Most families own multiple cooking devices (generally three, but sometimes exceeding six) and use multiple types of fuel. Virtually all families have at least one wood-burning stove, many of which are homemade using recycled materials such as tractor discs, 55-gallon metal drums, or cinder blocks. Other cooking devices include gas stoves, electric crock pots, electric stoves, and microwaves.

- The most commonly-used fuels are gas and wood (including wood from trees, shipping pallets, and garbage dumps), but poorer families with access to the garbage dump also burn clothing, shoes, plastic, rubber, shipping foam, and other materials in heating and cooking stoves.

- Diets and cooking habits are relatively consistent across the population. Breakfasts tend to be quick meals of coffee with eggs, cereal, or baked goods. The typical diet in Nogales centers around meat (primarily chicken, beef, and pork) cooked on a daily basis. Beans are generally cooked only once a week in large quantities (0.5-1 kg). Tortillas are often store-bought and heated at mealtime. Many families cook large soups and stews once a week and special dishes like menudo or barbacoa once or twice a month.

- Household cooks decide which stove to use for a given meal based on the season and temperature, the food to be cooked, and available fuels. During the cold winter months, cooks are more likely to use indoor wood-burning stoves that also heat the house, whereas during the summer they are more likely to use gas stoves, electric pots, or outdoor wood stoves. Slow-cooking foods like beans, stews, menudo, and barbacoa are generally cooked on wood stoves because gas and electricity are significantly more expensive. However, families with electric crock pots will often use these to cook slow-cooking foods during the summer months.

- Daily schedules of household cooks can significantly influence cooking practices and stove use. This is particularly relevant in Nogales, where seasonal employment, night work, and long factory shifts can make household cooks essentially unavailable for periods of the year. During these periods, households will often rely on faster-cooking stoves (gas, electric, and microwaves) and on the purchase of prepared food.

- Families also use stoves to heat water for coffee (year-round), washing dishes (year-round), and bathing (six to nine months of the year).

- The safety of cooking stoves is a serious concern. All of the focus group and workshop participants knew of people whose houses had burned down and whose children had been injured because of common cooking and heating activities. In addition, the 55-gallon drums used to make stoves often contain dangerous chemical residues and the metal degrades quickly when exposed to fire. Many household stoves are in disrepair.

- Home ownership status and plans for construction and renovation affect participants' interest in different types of stoves. Renters and home owners planning renovation are typically more likely to desire portable stoves.

- Aesthetic preferences vary. While many cooks were immediately turned off by stoves constructed from recycled metal cans, others were excited by the possibility of using locally available and recycled materials. Similarly, some cooks were impressed by brick ovens but others preferred a more modern-looking metal one.

In focus groups and interviews, researchers confirmed these findings and sought additional information. While reports about the extent of wood burning for seasonal heating in Nogales varied, wood burning for heating during the winter appears to be fairly common. Most of the questionnaires done by ITN students in their neighborhoods and workplaces indicate that households are burning wood for heat. In a quick visual inspection one winter morning, researchers observed burning in more than 10 percent of the houses within one colonia, but some individuals interviewed suggest that burning rates are actually much higher.

Rates of Wood Burning in Restaurants

Of the 46 restaurants surveyed, 5 reported burning wood during cooking, 4 in a barbecue and 1 in a wood stove. Due to the small number of restaurants that reported burning wood to cook, little can be concluded from the survey data. The researchers also conducted participant observation in the colonias where the household surveys were conducted, and there they observed more frequent burning of wood and charcoal at the small food stands operating along the streets than in restaurants in the city's center.

Summary

Building upon data from prior studies, researchers conducted surveys, interviews, and focus groups to investigate garbage and wood burning in Nogales, Sonora. In order to determine whether small-scale burning is related to access to goods and services, which are influenced by both household-level and neighborhood-level characteristics, researchers also collected data on factors such as household income, types of containers used for storing garbage, and any types of stoves used for cooking. Researchers then compared burning rates according to neighborhood-level factors (such as poverty index) and household-level factors (such as income) to identify influences on burning.

In general, people in Nogales burn to address specific needs for managing solid waste, cooking, and/or heating the home. There are strong relationships among the location of a neighborhood, age of the neighborhood, garbage collection, and burning. In households where garbage burning is occurring, individuals explained their actions either as a response to problems (lack of collection service) or as a preventive measure to avoid problems with dogs, insects, and illness. Study participants explained that wood was burned as an alternative or supplement to other sources of fuel in cookstoves and heaters. There is considerable variation in household income levels within an AGEB unit. This variation is reflected in the level and frequency of burning, especially of wood which depends to an even greater extent on the availability of individual household resources for purchasing alternatives than does garbage burning.

This study was not designed to collect data that could be used to determine absolute levels of burning across Nogales (see Chapter Two). Instead, the goal of the study was to use the available

resources to gain an understanding of the causes and extent of small-scale burning and then to utilize that understanding to develop and test an action plan to reduce burning within Nogales. Mechanisms for reducing burning within Nogales are presented in Chapter Five.

Chapter Five: Mechanisms for Reducing Burning

This chapter addresses possible mechanisms for reducing the burning of both garbage and wood in Nogales, Sonora. With regard to garbage burning, the most direct solution is to address garbage collection. During the summer and fall of 2007, the municipal government of Nogales made significant changes to the city's collection services. These changes are described below and in Chapter Six. Because some of the necessary changes at the municipal government level require considerable resources, it is important to also consider other options and approaches for creating an integrated waste management system. Many of those changes are described in the following paragraphs; those that were judged most likely to succeed in Nogales were incorporated into the Action Plan outlined in Chapter Six. With regard to wood burning, this chapter discusses several initiatives for providing alternative stoves to people using wood burning stoves and heaters, as well as efforts to introduce thermally efficient housing construction to individuals and organizations responsible for building homes in Nogales.

Reducing Garbage Burning

As discussed in Chapters Three and Four, garbage burning has been reported as a problem in Nogales for more than a decade, both at the point of the individual household and/or small business and at the municipal landfill. Though some burning does occur for other reasons, the vast majority of garbage burning was reported to be due to inadequate space or containers for storing or disposing of municipal solid waste (MSW) that is not collected. At the household level, burning is therefore directly linked to insufficient or irregular garbage collection service and lack of garbage storage containers, so specific strategies have been developed to improve service and provide containers.

As described in Chapter Three, steps to address burning at the city landfill were taken in the late 1990s, with the development of a new landfill south of town and the conversion of the original landfill to a transfer station. Nevertheless, burning has occurred at the transfer station since that time, both by employees to reduce the volume of waste and by *pepenedores* (pickers) in their attempts to recover valuable metals such as copper. Lack of capacity at the new landfill and the transfer station is a significant problem, and government leaders have identified a number of strategies for reducing the volume of waste being disposed of. In addition, neighborhood leaders, school officials, and others within the community have come up with ideas and programs for diverting materials from the waste stream. The first section below describes various mechanisms for improving solid waste management in Nogales. The next section then outlines various programs for removing materials from the waste stream. Because all of these initiatives are new – most have begun within the past six months – it has not been possible to fully evaluate their effectiveness. Nevertheless, the outcomes of these initiatives were taken into account in the development of the Action Plan described in Chapter Six.

Improving Solid Waste Management

Since the fall of 2006, city officials in the planning and public services departments have been working to improve municipal solid waste (MSW) management in Nogales, Sonora. In March 2007, officials in the Department of Planning, Urban Development, and Ecology asked the

small-scale burning team to share results of the survey described in Chapters Two and Four to include in their garbage service expansion project, entitled "The Management of Non-Toxic Solid Waste and Sealing the Open Landfill" ("*Manejo de Residuos Sólidos no Peligrosos y Clausura del Tiradero Abierto"*). This project assessed the current state of municipal garbage collection and included a proposal for a loan from the North American Development Bank (NADB; *Banco de Desarrollo de América del Norte* or *BDAN);* the proposal first had to be approved by the Border Environment Cooperation Commission or BECC (*Comisión de Cooperación Ecológica Fronteriza* or *COCEF*). The project laid out four goals: (1) to buy new diesel garbage trucks; (2) to close one cell at the landfill; (3) to build a new transfer station; and (4) to enclose the landfill.

In April 2007, Nogales residents voted on a proposal to charge a 15 peso-per-month fee to improve garbage collection for one year. The fee was to be used only for purchasing new garbage trucks and would be assessed once the trucks had been bought and put into service. Voters approved the initiative, so the 15 pesos were added to household utility bills each month, once the trucks were bought and put to use in fall 2007. Some residents opposed and protested against this initiative, mostly because they feared the fee would become permanent. Others thought they would not benefit because they did not receive regular trash service. Residents who do not pay for water service will not pay the trash fee, even though city officials argue that all residents will see improved garbage collection in their neighborhoods. Government officials were looking for other ways to collect the garbage fee from all Nogales residents.

In May 2007, officials presented to residents a proposed Integrated Management System for Urban Solid Waste. The main action items in the new management plan can be grouped into the four following categories:

1. Improve the collection system, including collection routes and buying new equipment
2. Relocate, redesign, and reequip the transfer station
3. Close Cell A at the municipal landfill and the open garbage dump in the Colonia Bella Vista
4. Construct the new Cell B according to norms and regulations
5. Buy equipment for street sweeping

NADB and BECC approved the loan to improve MSW management, but required the Department of Planning, Urban Development, and Ecology to present the plan to the public for approval. A meeting was held in August 2007, during which an official from the Department presented the integrated trash management plan to representatives from various civic organizations. Meeting attendees voted in favor of the proposed garbage management plan. The following paragraphs summarize the steps taken to improve MSW management in Nogales that have direct implications for the level of garbage burning occurring in the city. Actions such as the closure of a cell at the landfill are not discussed.

<u>Improve MSW Collection</u>

To improve the collection of MSW, officials first investigated the existing system, paying attention to routes, equipment, and the quantity and quality of collection. With the help of

garbage collectors, officials outlined the routes, identified average quantities of trash collected per route, and counted the number of houses or lots per route via aerial photographs. When they began, Nogales had 27 programmed routes, divided by the train tracks into two sectors, east and west. Four other routes were included to collect trash from permanent garbage containers located downtown, bringing the total number of routes to 31. Often routes were fragmented so that collectors only collected from certain streets within a neighborhood and not everyone in the neighborhood received service. The routes were not designed to account for Nogales' rapid population growth. Also, the amount of trash collected varied for each route, thereby causing the trucks on some routes to fill up faster than trucks on other routes and not allowing collectors to pick up garbage from all houses in a neighborhood.

In 2005, city garbage workers collected around 100,000 tons of trash. Average cost to collect garbage runs around 500 pesos per ton. A goal of the Public Services Department is to reduce this cost to 380 pesos per ton. To reduce costs, collection must be made more efficient. In the previous garbage collection system, with 31 daily routes, 34 teams of 2-3 workers each collected garbage from Monday to Sunday on three shifts a day. City officials redesigned the system so that a total of 27 teams of collectors work from Monday to Saturday, divided between morning and afternoon shifts.

The city government also redefined the garbage routes, which now total 53. Officials divided the city into 3 sections with each now receiving collection on the same days each week, reducing the amount of time collectors spend driving around the city between routes and the transfer station. Fifty of the new collection routes are due to receive trash service twice a week, and the other three will get daily pick-up. The new schedule went into effect on June 18, 2007. A local newspaper printed the schedule, informing residents of the days they will receive trash service. The schedule also stated that the city had 15 trash trucks in service and that 20-40 new containers were installed in the city for public use. A copy of the announcement can be found on the city government's website (www.nogalessonora.gob.mx) at the link, "Avanza de rediseño de rutas."

The following 39 trucks were used to collect from the initial 31 routes:
- Compactor Trucks less than 5 years old: 4 trucks with 20 yard capacity, 4 trucks with 10 yard capacity
- Compactor Trucks less than 10 years old: 2 trucks with 20 yard capacity
- Compactor Trucks less than 15 years old: 10 trucks with 20 yard capacity
- Compactor Trucks more than 20 years old: 3 trucks with 20 yard capacity
- 3 Open top Trucks less than 10 years old
- 8 Open top Trucks more than 10 years old
- 2 Open top Trucks more than 15 years old
- 3 Open top Trucks more than 20 years old

Because most of these trucks were so old - about 70 percent of all trash in Nogales was being collected with trucks that are older than 10 years - breakdowns were a significant problem, leaving the trucks out of commission while being repaired. If all of the trucks had been in good condition, they could have collected a total of 177 tons at a time. However, based on studies conducted by city officials, the compactor trucks less than 10 years old worked at about 85 percent of their capacity, and the trucks 15 years and older only worked at about 55 percent of

their capacity. Therefore, the actual capacity of the trucks was around 116 tons. Garbage collectors on average pick up 257 tons a day, meaning each truck and team of workers was making 2.2 trips per day.

The city government solicited suppliers for the new garbage trucks and selected one. Retaining the 10 existing trucks less than 10 years old, city officials purchased 16 additional trucks – 12 compacting trucks with 20 yard capacity and 4 compacting trucks with 10 yard capacity. The smaller trucks were ordered because they would be able to climb steep mountains and handle rougher terrain of the unpaved roads, especially in the peripheries of the city. These trucks would collect the trash in such hard to reach places and bring the trash to the larger collection trucks. With these 26 trucks, officials estimate a potential daily collection of 264 tons, based on two trips per day per truck. The city purchased diesel vehicles so that if it becomes feasible to use biodiesel the trucks can readily be converted.

Address Issues at the Transfer Station

Once the garbage is collected, it is taken to the transfer station prior to being transported to the city landfill for final disposal. In addition, residents can drop off their own solid waste to the transfer station. Sometimes when residents of a neighborhood are not receiving regular garbage pick-up, they take their own waste to the transfer station, or pay someone from the neighborhood to collect and take it. In February 2007, researchers were told that there was no charge for dropping off garbage. However, as of May 1, 2007, the transfer station began charging private companies and industries 100 pesos per ton, which is used for maintenance of the landfill. This fee had always been in place, but it was not being enforced. This fee mostly affects the private collection companies who are contracted by other companies to collect trash. In interviews conducted for this study, city officials argued that this price was still low when compared to privatized landfills, like Agua Prieta, where they charge up to 350 pesos per ton.

Buy Equipment for Street Sweeping

General clean-up of the city streets was included in the Integrated Management System. The municipal government bought two street sweepers for the main streets of Nogales, including the Periférico, Obregón Avenue, and Plutarco Elías Calles Avenue. In November 2007, they began to clean these streets three times a week in the early morning hours. These streets used to be swept manually. Now the people who used to sweep the main streets have moved to clean the secondary streets downtown.

Beginning in the spring of 2007, employees of the Department of Public Services teamed up with the Department of Social Services (*Desarrollo Social*) to organize a series of neighborhood clean-ups, focusing particularly on large items that cannot be picked up during regular garbage collection. Colonia representatives could sign up with Social Services for a neighborhood clean-up day. On this day, residents would place large items such as branches, furniture, and tires at their curbs and a garbage truck would come by and remove them. During some events, municipal government employees went to help residents clean up the streets, picking up trash and sweeping leaves and dirt.

During June 2007, additional street clean-up days were scheduled in different locations every day of the month, except Sundays. On those days, crews only swept and picked up trash on the street; residents did not place out large items for pick-up. Those clean-ups began at 5am and were scheduled until 10pm every day.

Both types of clean-up days generated positive results. However, researchers noted a lack of communication between the neighborhoods and Public Services, resulting in the scheduling and re-scheduling of clean-up/pick-up days, often several times. Confusion over the difference between the pick-up and the clean-up dates caused frustration among residents who thought they had missed the date for pick-up. Similarly, on a few occasions clean-ups in two neighborhoods were scheduled for the same day and time though city crews only went to one location, leaving residents in the second neighborhood waiting for someone to show up. When combined with better service, the clean-up campaigns have the potential to demonstrate to residents that garbage can be removed from their streets without the need for burning.

Related Issues

Privatization

As the municipal government investigated ways to improve garbage collection, officials looked into privatization. There were various proposals and offers from private companies to pick up Nogales' trash. In the end, the proposals for citywide privatized trash collection were rejected and the municipal government decided to retain control of MSW management. Nevertheless, one company was contracted to collect trash from particular public containers placed in different communities throughout Nogales. Thirty such containers, varying in size from 1 to 3 cubic meters, have been installed in communal places where residents often put their garbage. The goal is to install 100-120 of these containers throughout Nogales. The contracted company has its own garbage truck and is supposed to pick up trash every day from these public containers.

Containers/Storage

Some residents indicated that people burn garbage because they do not have a place to store it. The city does not take responsibility for providing household containers, as it only focuses on providing containers in public plazas and parks. Most people who do have waste storage said they use *tambos*, or recycled 55-gallon oil drums, as garbage containers, especially in areas that receive irregular collection service. These drums are over two times larger in size than permitted under the Regulation of Public Services, which calls for containers to be no larger than 100 liters (26.42 gallons). However, while such containers are technically in violation of the Regulation of Public Services, the restriction on size is not enforced.

The tambos are made of either plastic or metal. The garbage collectors prefer the plastic ones, as the metal ones are significantly heavier. However, some residents noted that in many areas of the city, especially those on the tops of hills, the heavy winds could easily tip over plastic containers. Also, many residents are afraid of container theft, especially in areas where garbage containers are scarce. Plastic containers are especially valuable as they can be used to store water, though depending on the source of the container there may be concerns about chemicals leaching into

the water. Some residents employ methods to deter thieves, such as pouring cement in the bottom of a metal container, or chaining it to a fence. These actions however prohibit collectors from lifting the containers to deposit the garbage into the truck. People can and often do burn inside metal containers, whereas people are not able to burn in plastic ones. Garbage collectors noted that sometimes when people burn in metal containers, they leave the ashes and put more garbage on top for collection. Not only does the ash make the container very heavy and create clouds of dust when it is being emptied, but it can also be dangerous. If embers are still alive, they can catch fire in the truck or even at the landfill.

Researchers observed many different kinds of garbage containers throughout Nogales. According to the garbage collectors, the easiest containers for them to handle are plastic cans or tied garbage bags. The most difficult are large metal containers, due to their weight. Also difficult are immovable trash receptacles, such as those cemented into the ground, unless the garbage is placed inside plastic bags. Oftentimes, the garbage in these receptacles is loose and collectors have to remove it piece by piece, emptying it into another small plastic bin to throw into the garbage truck. If the container is extremely large, collectors must climb inside and remove the garbage bag-by-bag or piece-by-piece.

In places where garbage is picked up every day, many residents and small business owners do not use cans or storage containers. They hang small plastic bags from fences or telephone poles, or place piles of trash bags outside on the curb. Oftentimes, if no garbage piles or cans are on the street, and if the workers know their routes and the people along it, they knock on doors or poke their heads inside a business asking for the garbage.

Besides cans, researchers noted other kinds of creative garbage container solutions, often made from other items. Old refrigerators tipped on their backs with “BASURA” written on the side are often used for garbage. Sometimes the refrigerator door is still attached and used as a lid to keep out animals. An interesting receptacle observed by researchers is a shopping cart, welded to a pole, and lifted about 4 feet off the ground to deter dogs. Also, small cages are used, either on the ground or hung from a fence.

Though some individuals suggested that MSW management would be improved if containers were made available to residents, one city official interviewed for this study was not convinced that giving out containers would be an effective solution. He noted that eight years ago the Department of Public Services gave out 55 gallon-drums for this purpose, but that did not solve the problem. According to this official, the solution lies in education and creating a culture of throwing away trash properly.

An official from the Department of Urban Development, Planning, and Ecology also pointed out the importance of having the right type of container. He recalled how the department previously installed a large dumpster in one neighborhood, and many people used it. However, children were most often sent to throw away trash bags, and their attempts to throw the bags over the high walls of the dumpster were not always successful. Many bags never made it inside. Instead, they opened in the air, causing the trash to scatter around the dumpster and creating more of a mess. Then, because the city did not have trucks that could lift the dumpster, the garbage collectors had to go inside and empty the garbage by hand.

Nevertheless, in the fall of 2006, the Department of Public Services installed approximately 40 blue metal trash cans in the downtown area, as part of a campaign to clean up the area. These trash cans were lined with plastic bags and bolted to the ground. Each had a metal lid with a small opening, allowing people to throw away their personal trash items, but not allowing people and businesses to throw away large items or trash bags. These trash cans were placed on trash routes with regular trash service.

Summary of Pilot Action to Build Community Garbage Areas

In focus groups conducted in April and May 2007, the research team asked participants what types of containers they preferred to have in their neighborhoods. Members of the team also talked with garbage collectors and rode along with them on their collection routes to understand from which types of containers garbage was easiest to collect. Researchers also evaluated cost and accessibility of different containers. After this preliminary work, the research team worked with residents of Colonia Artículo 27 to explore the use of public garbage storage areas.

Community members and members of the research team designed a storage area that consisted of 4-12 plastic and metal 55-gallon drums, donated by CR Bard, a maquila in Nogales. The plastic containers were the types of garbage containers preferred by most of the collectors researchers interviewed, however, some metal ones were used as well because there were not enough plastic containers available. But to keep out dogs, and prevent theft, a fence was constructed around the trash cans, with a gate so collectors could remove the trash cans. Three enclosed garbage areas were constructed in strategic points in Artículo 27, which residents already were using to dispose of their garbage.

Most of the enclosed garbage storage areas worked as collection sites, however, in one of the sites, all the plastic containers were stolen, as such containers are often used to store water and are somewhat valuable. At one storage area, community members drilled holes near the bottom of the cans so people would not be able to store water in them.

When the research team asked people in other neighborhoods if they would like to try public garbage containers, many said no, primarily because of lack of a place for such a container within the colonia. Most residents were unwilling to have it located near their houses as they feared it would just collect garbage and create a mess. However, if the container was too far away, residents said they would not use it. Many people said they would rather have a personal garbage can by their house.

Miércoles Ciudadanos (Citizen Wednesdays)

Immediately after taking office in the fall of 2006, the new municipal government initiated a program, called *Miércoles Ciudadanos* (Citizen Wednesdays), to increase communication between citizens and the government. The program is an initiative of the National Action Party (*Partido Acción Nacional* or *PAN*) and has been instituted in other cities of Sonora; this was the first such program in Nogales. As part of the program, the mayor and the directors of every municipal department hold weekly meetings to listen to the needs of the city's residents.

Residents arrive and take a number for the particular department they want to see. When their number is called, they can present their need and ask for assistance.

Reactions to these meetings have been generally positive and the meetings are well attended. Some interviewees who have participated in this program say it is the first time they felt their concerns were being heard and the issues actually addressed. This program has been important to the small-scale burning project because it has provided a venue for Nogales residents to access their municipal government and ask for help with certain projects or ask for services for their community; for example, residents voiced their concerns regarding garbage service. The opportunity to present their needs in front of the board of city officials gave some residents confidence that action would be taken.

Removing Materials from the Waste Stream

Another approach to addressing the critical need for improved garbage collection and the lack of landfill capacity is to remove materials from the waste stream. The following sections describe three alternatives – composting, recycling, and reuse – that have been attempted in Nogales.

Composting

People sometimes burn so animals are not attracted to the food in their garbage. Separation of the organic and inorganic waste, and then composting the former, can help reduce the overall amount of waste and especially that which attracts pests. In Nogales, composting has been attempted at several levels.

The Nogales Municipal Nursery: The Department of Ecology maintains the municipal nursery, located on Avenida Tecnológico, near the colonias of Jardines de la Montaña, El Rastro, and Colosio. Two people staff the nursery, and it is open six days per week. In addition, a family lives on the grounds of the nursery and its members act as guardians. The two workers care for several thousand young plants and maintain compost piles. Employees attended a composting workshop in Hermosillo, Sonora (organized by the *Secretaria de Medio Ambiente y Recursos Naturales* or *SEMARNAT* and the *Instituto Nacional de Ecología* or *INE*) and are currently testing different composting options and mixtures. One method involves making piles of dirt, leaves, food waste, sawdust, and a small amount of cattle manure. Another involves making compost in long strips (chorizos) consisting of manure, leaves, and small branches (to provide ventilation to the compost). A third method involves the same ingredients as the previous method, but the compost is made inside a container. Initial results indicated that the third option was working the fastest. After a week in the container, the mixture was already at the same consistency as the compost in long piles, which had been outside and exposed to the summer monsoon rains for about three months.

Employees of the city Ecology Department have also investigated the use of worms to aid in the composting process. Though it is possible to buy worms, cost is a concern. Employees may find worms near the nursery and put them in the compost piles or containers.

Employees also expressed a desire to use more organic food waste in the compost. They are currently investigating the possibility of obtaining food waste from supermarkets and restaurants. They would also like to set up a program to collect household organic food waste for the compost piles. The compost will be used to fertilize the plants being grown at the nursery. The city would like to expand this operation so that compost can be given away or sold to local residents for use in community green areas, personal gardens, and reforestation projects.

The nursery is available to conduct workshops. Students, teachers, and community activists from the Association for Reforestation of Ambos Nogales (ARAN) attended a workshop at the nursery in November 2006, where they learned how the nursery operates and helped to collect dry leaves to add to the compost pile. One of the city employees from the nursery led composting workshops at ARAN's fall 2007 retreat. Ecology students from Escuela Secundaria General 3, a secondary school (equivalent to grades 7 to 9) across the street from the city nursery, perform various tasks at the nursery.

Schools: Several schools within Nogales have developed programs to make and use compost. At the high school level, both the Centro de Estudios Tecnológicos industrial y de servicios N. 128 (CETis 128) and the Colegio Nacional de Educación Profesional Técnica (CONALEP) have incorporated composting into their ecology and gardening projects. At CONALEP, for example, students must participate in social service projects to graduate. One option for fulfilling social service requirements has been participation in ecological projects, and one project that was underway for several years was the production of compost. Organic matter from local supermarkets and food vendors was collected at the school, and the students constructed compost bins in which they placed the material. They were then responsible for turning and adding to the compost pile on a weekly basis. In May 2007, in recognition of their hard work and dedication to the environment, two of these students were awarded the Municipal Prize for Youth in the Category of Caring for the Environment (*El Premio Municipal de la Juventud, Cuidado del Medio Ambiente)* by the City Government. The supervisor of their club reported that during the program some students encouraged their families to engage in composting practices at the household level. In addition, the supervisor herself, along with other members of ARAN, created their own household composting systems.

Individuals: Some people who have moved to the city have brought sustainable farming practices with them, including composting. Through focus groups and interviews, researchers met individuals who composted their household food waste. For example, one woman in Colonia Colosio composted by placing fruit and vegetable waste around the base of her plants. While her system worked, she was interested in learning different composting techniques; she complained that her method often produced an odor and attracted flies. Also, leaders of World Vision, an international non-governmental organization which recently established a program in Nogales, also expressed interest in learning composting techniques to teach in the community as part of their gardening classes. Researchers from the small-scale burning study helped coordinate resources for the workshop.

Neighborhoods: Residents from various neighborhoods in Nogales, Sonora have worked with ARAN members and local high school students to develop green areas in their neighborhoods. Their work involves cleaning up trash, planting trees, building "trincheras" to control erosion,

creating walking trails, and building community compost bins. In two neighborhoods, residents constructed public compost bins where neighbors could discard food and yard waste. Other people in the same neighborhoods have built their own compost bins after learning about composting through their participation in ARAN and school ecology groups.

Summary of Pilot on Community Composting

As part of this study, researchers identified a resident "compost expert" in Colonia Colosio who has been using her food scraps to fertilize plants. She was interested in sharing her experience and knowledge as well as learning different techniques. At the residents' suggestion, research team members collaborated with World Vision, which has begun working on various projects in the colonia. Residents wanted to learn more about composting in order to develop an educational program to grow and sell plants. A preliminary planning session was held in June 2007 to discuss a composting workshop in Colosio for July. Representatives from Colosio, World Vision, the City Nursery, UA, and an ARAN member who had successfully implemented a community green area and compost bin in Colonia Villa Sonora attended the meeting. At the meeting, participants discussed the possibility of creating a green area and community compost bin. Eventually the participants decided that promoting household composting would be more effective for the present. Residents did not want to take their waste far away and the compost they produced at home could be used on their own plants.

Fifty people attended the workshop in July 2007. Resident experts from the colonia and the city nursery explained the importance of composting and the basics of separating organic waste from inorganic waste, and describing what could and could not be composted. They presented various methods and containers and also discussed methods of planting and caring for plants. The city nursery donated twenty plants, which were given away to workshop participants along with instructions on how to care for them. A trip to the City nursery to see the composting and planting operations there was planned for early August.

Recycling: Collecting and Managing Materials to be Processed Elsewhere

A second alternative for reducing the amount of garbage that must be taken to the landfill is recycling. As described in Chapter One, recycling can reduce the cost of collection and at the same time reduce the volume of waste, thus making it possible for the municipal government to improve management of the material that remains in the waste stream. For example, if less garbage were generated per household, the existing garbage trucks could handle a greater number of households.

In Nogales there exist two types of recycling – informal and formal. Formal recycling consists of regular collections of recyclable materials. At this time in Nogales, this type of recycling is available only to private businesses and the maquiladoras. Informal recycling involves people who look for waste and sell it to small businesses.

Formal Recycling: There are various businesses and maquiladoras that participate in formal recycling in Nogales, Sonora. These companies collect and sell recyclable materials from other maquiladoras. One of these businesses, Transformadores de México (TOM), has been in

Nogales, Sonora for 12 years. The company collects materials such as paper, cardboard, plastic, glass, bronze, copper, aluminum, antimony, zinc, and iron. A company official told researchers that TOM collects wastes from 80 percent of the businesses in Nogales. The company buys materials from the businesses, cleans them, and then sells them to other collection centers and businesses, depending on the type of material. For example, materials made of fiber are reused to make napkins and toilet paper. Copper can be made into bullions or wire for lights. Items go to Phoenix, Los Angeles, or Mexicali. The businesses pay for the collection of garbage, but TOM pays the businesses for their recyclable wastes. The amount that is paid depends on the volume of material and the market price at the time.

At this time, TOM does not collect materials from households, but the company has conducted clean-up campaigns in various colonias. The company also has a program with some local schools to collect their waste paper.

There are two recycling businesses that specialize in the collection of plastic. One is SVR Plastic, which began doing business in Nogales, Sonora in late 2005. The company recycles PVC, polyethylene (plastic bags), PEB (plastic bottles), hoses, purges (plastics with paint), polypropylene, plastic racks, and spools. The minimum quantity that the company will purchase is 100kg. The company collects materials from maquilas and takes it to SVR Plastic for cleaning and compacting. It pays 4 to 28 cents per kilo, depending on the material, and then sells and exports the majority of it to factories in Los Angeles, CA, but at times to China, where it is turned into gloves, boots, and plastic suits.

SVR Plastic is recognized as a maquila, not as a recycler. Thus, at this time the company can collect only from maquiladoras and does not have permission to purchase from individual citizens. The company does have an agreement with the local government to buy plastic that the *pepenedores* gather at the municipal transfer station.

Recicladora del Yaqui, with more than 12 years working in Nogales, Sonora, also recycles plastic. The company compacts and grinds the plastic to sell to other factories. The spools, for example, are sold to make footwear, like the heels for shoes. The materials are sold where the prices are the highest, at times in Mexico or China. The company also buys directly from maquilas and businesses, not from citizens, but company officials are considering a program to buy plastic from citizens. The company has a program with Coca-Cola to buy plastic soda bottles. Company officials want to begin a program with Nogales schools to collect their bottles.

Informal Recycling: While there is no program for collecting household materials, there is a fairly large informal recycling system composed of small recycling centers, the majority of which are located in the center of Nogales. Members of the research team interviewed people who worked at three different recycling centers, where they buy various types of metal, such as aluminum (around 10 pesos/kilo), copper (40 pesos/kilo), bronze (between 9 and 15 pesos/kilo), and cans (15 pesos/kilo). The interviewees also identified a business in Nogales, Arizona that buys metal and glass (at 1 peso per returnable bottle) to sell to the bottlers.

Many people collect cans and other types of metal to sell to the small recyclers. Some collect in their neighborhoods or their houses. Others collect in the streets in the center of town. The

majority of the garbage collectors collect things to recycle during their collection routes. Also, there are various *pepenedores* (10-20) who live on or near the municipal transfer station. They go through the garbage that arrives there and take out the things they can sell. But by the time the garbage arrives at the landfill, many people have picked through it, so the most valuable items usually have already been removed.

Implementing a Recycling Program in Nogales

Officials in the Office of Urban Planning in Nogales Sonora have developed a new recycling program as part of their integrated management of MSW. In September of 2007, officials presented this recycling plan to Nogales residents. Their goal is to recycle at least four tons of trash per day through September 2009 (the end of their current term of office). At the meeting, officials discussed the benefits recycling would provide residents, which are discussed below.

1. The Eco-Peso: By recycling at certain city centers, residents would earn eco-pesos, redeemable at the city government offices for city-related transactions like fees or fines. One eco-peso would allow someone a 10 peso discount.
2. School Recycling Programs: This program would involve collecting paper and plastic from schools and recycling them at various recycling centers in Nogales, Sonora. The money earned would be used towards building playgrounds and soccer and basketball courts. This program would involve the help of retired people and people currently in rehabilitation facilities.
3. Reducing waste in the Landfill: The landfill will last much longer if Nogales recycles, simply because less trash will end up there. This will benefit residents because they will not have to pay the costs of opening another landfill.

Recycling: Collecting and Managing Materials to be Processed Locally

Though most of the recycling done in Nogales involves collecting and managing materials to be transported outside the city, state, and even country for processing, the local production of fibrous concrete provides an alternative for the local processing of recyclable materials. This is a particularly attractive option for materials such as paper that have a lower resale value and for which the costs of transportation may outweigh the value of recycling. Data from the household survey indicate that Nogales residents respond to the market in their decisions about whether or not to recycle. Materials such as aluminum and copper have a high resale value, so recycling them is both cost-effective and attractive to local residents. In contrast, as shown in Table 5.1, data from the survey indicate that paper and cardboard are the items most often burned in Nogales. Consequently, new mechanisms are needed to remove paper from the waste stream.

Table 5.1 Types of Waste that Are Burned in Nogales

Paper and Cardboard	Branches and Leaves	Plastic	Glass	Food	Other*
39 (87%)	34 (76%)	31 (69%)	12 (27%)	9 (20%)	12

The production and use of fibrous concrete provides one option for recycling paper locally. In 2005-2006, a team of researchers at the UA, working with community partners and supported by the ADEQ, conducted a project entitled, “Thermal Construction and Alternative Heating and Cooking Technologies.” The team investigated various technologies, some of which offer

solutions to reduce garbage and wood burning. One of these projects involved an alternative building material called Fibrous Concrete (*Concreto Fibroso* or *ConFib*; also known as papercrete; see www.livinginpaper.com) which produces bricks of high thermal mass and therefore could reduce the need for heating during cold winter months. ConFib is a mixture of 50 to 80 percent recycled paper, water, sand, and Portland cement; other materials such as ash and straw can also be added to the mix. Fibrous concrete can be made with newspaper, office paper, cardboard, workbooks, phone books, and magazines (although magazine paper cannot be used alone). The ConFib mixture can be poured into molds to make adobe style bricks, or it can be poured into slip-forms (for more information about making ConFib, see Appendix G).

This technology was selected by community leaders and residents in Nogales, out of a number of different alternative building materials such as rammed earth and sandbags, as the alternative most likely to be accepted and adopted in Nogales. Fibrous concrete was favored because it can be used to construct homes that look like standard cinder block homes and are thermally efficient, secure from theft, made of readily available materials using local masonry expertise, inexpensive, and both fire and insect resistant. It also converts a waste product (used paper) into a resource and can be made locally.

Because the alternative technologies project assessment indicated that further attention should be paid to ConFib, and also identified potential problems such as the need for large quantities of water, paper, and sand which must be transported to the production site, a series of nine ConFib workshops were held, beginning in the summer of 2006 and lasting through spring of 2007.[5] Each workshop was designed to introduce the technology to community members or teach participants further steps towards building a ConFib house. Experts were identified and brought to workshops to help facilitate. These experts included: a professor of engineering at the Instituto Tecnológico de Nogales who had been working with his students to test the material, a community leader in Colonia Flores Magón who had been experimenting with the material, and Barry Fuller, an Alternative Materials Specialist who has been working with ConFib for over four years and was instrumental in teaching the research team and community members the basics for building ConFib structures. Also, as community members gained more experience with the material, they in turn taught newcomers about ConFib. Most of these workshops were held to instruct people in the basic steps of making ConFib. One workshop also introduced the tow-mixer, which uses a differential rear-axle to mix the material (see http://www.livinginpaper.com/getyours.htm). After the workshop, the machine shop instructor and a group of his students at CONALEP constructed a tow mixer to be used in the community. Two other workshops focused on future steps for constructing a ConFib structure, including the foundation and the roof.

During the course of this study, three different ConFib initiatives began in Nogales, Sonora. As an example, one of these initiatives is underway in Flores Magón. After learning about the material, a community leader in this colonia decided he would build a demonstration room on his property. Once complete, he plans to have open hours when people can come by and see the room so they can see how sturdy the structure is, how well it holds up over time and in adverse conditions, and also to test the materials' thermal properties. The foundation workshop was held in this location in February 2007. Currently, the foundation and part of a wall using a slip form

[5] A special thanks to the University of Arizona's Magellan Fund for providing funding to facilitate these workshops.

method have been constructed at this site. A slip form has also been built for the bottom portion of the other three walls. More than fifty bricks have been made and are ready for use at this site.

The second initiative was begun at the Casa de Misericordia in Colonia Bella Vista. A community member was selected to organize the community and organize workshops, and he facilitated a number of introductory brick-making workshops there, not only for members of the Bella Vista community, but also for members of other communities, schools, and professional groups. Though more than a dozen bricks were made at the site, the bricks were destroyed by vandals when they were left to dry. The mixer constructed at the site was also destroyed when vandals stole many of the metal parts. As a result, a fence was constructed around an area where the bricks could dry and materials could be stored, and an enclosed area to collect paper was built. Program leaders are now looking for funds to resume the project.

The third initiative grew out of the ConFib project at the Casa de la Misericordia. The director of the Casa presented ConFib to members of the Asociación de Profesionales en Seguridad y Ambiente (APSA), a group of maquiladora employees who meet biweekly and work on environmental projects. An APSA member who worked at the maquiladora Alcatel organized other APSA members to begin a ConFib project. The group decided to build a 3-room ConFib house for an Alcatel employee who was living in a makeshift house at the time. APSA members donated money to buy a plot of land on which to build the house and organized an introductory workshop at the Casa de la Misericordia. To get the project moving more quickly, on April 19, 2007, the Alcatel employee organized a contest among maquiladoras to build as many ConFib blocks as possible in one day. Eleven teams from different maquiladoras participated, each team consisting of three people. In the end, over 860 bricks were made that day. In the fall of 2007, Alcatel managers and employees continued their project, making additional bricks and hosting Barry Fuller at a one-day workshop on foundations. Currently they are beginning to build the foundation of the house and organizing future construction days to have the house completed by Christmas 2007.

The development and testing of ConFib continued through the study period, both in Tempe, Arizona and in Nogales, Sonora. Investigations also continued into the potential for standardizing the brick-making process and scaling up production on a larger-scale. In February 2007, Barry Fuller introduced people in Nogales to a new type of brick which was compressed and also, due to the process by which it was made, could incorporate small bits of other waste materials, such as plastic. This type of brick offers promise for Nogales because of the difficulty of achieving 100% waste separation. In addition, regular ConFib structures can be up to two stories high, but the compressed brick could be used for structures of up to four stories tall.

Reducing Public Acceptance of Burning

As noted in Chapter Four, the majority of garbage burning that was reported in Nogales occurs because it addresses a significant problem – the removal of garbage and prevention of associated problems such as pests and potential for disease. Nevertheless, nearly one-fourth of the people surveyed who have regular garbage service burn their garbage. Individuals who burned their garbage despite having access to regular collection cited the presence of flies, a lack of garbage bags, the amount of garbage, laziness, and the desire to keep the yard clean as reasons for

burning garbage. In addition to improving garbage containers, reduction in burning among this group will require reducing public acceptance of burning as an option. Two approaches were examined: (1) legal measures and fines; and (2) public education and outreach efforts.

Legal Measures and Fines

The collection and disposal of household solid waste, including garbage burning, is regulated primarily at the municipal level by the Regulation of Public Services for the Cleaning, Collection, Transportation, Treatment, and Final Disposal of Non-hazardous Solid Waste in the Municipality of Nogales, Sonora (Regulation of Public Services) and the Regulation of Ecological Equilibrium and Environmental Protection (REEEP). Additionally, because atmospheric pollution is also a serious public heath concern, the burning of garbage and other solid waste is prohibited in the State of Sonora's Health Law (Ley de Salud).[6] As the law currently stands, the regulations pertaining to prohibitions of garbage and solid waste burning in Nogales exist predominately at the municipal level. Current enforcement practices do not adequately avert violations, though this seems primarily due to significant infrastructural deficiencies regarding garbage collection.

In order for any enforcement program to provide effective deterrence, improvements must first be made to the infrastructure, and educational campaigns should be launched to help change negative waste practices within the community. Only after these steps are taken can effective deterrence through enforcement programs take place.

Fines are another possible mechanism for reducing burning. The municipal government created twelve new inspector positions specifically to hold people accountable for garbage-related violations of the law, including garbage burning and unauthorized garbage dumping. The positions are funded directly from the municipal budget, which has allotted MX $688,020.00 (≈ US $62,957.21) to the program for 2007, and upon collection, the fines are put into the municipal treasury. The program does not receive any funding from the state or federal level.

The inspectors primarily patrol the low-income neighborhoods that receive the most irregular trash collection services, including the following *colonias*: Colosio, Solidaridad, Manantial, Las Torres, Colinas del Sol, Artículo 27, and Pueblo Nuevo. The Department instructs its inspectors to impose fines for dumping garbage in an undesignated place, burning garbage, having rubble accumulated in front of the house, having litter in front of the house, putting out garbage on non-collection days, and operating businesses in the street. Upon discovering a violation, an inspector can either give an official Notice of Violation or cite the violator immediately.

If the fine is not paid within the specified 72-hour period, the violator is supposed to receive a warning from the municipality. If the violator cannot afford to pay the fine, the alternate sanction is 4-5 hours of community service helping with the neighborhood clean-up campaigns. This alternative is determined at the Treasury office when the violator goes to pay the fine.

[6] Ley de Salud [Health Law], *as amended*, ch. V, art. 181, Boletín Oficial del Estado de Sonora [B.O.], 6 de Julio de 2006 (Mex.).

In addition to this new inspection system, there is also a long-standing hotline number (072) for citizens to call in order to officially report violations they have witnessed. The number corresponds to the Citizen Attention line (*Atención Ciudadana*), and the complaint is either transferred to the City Police or the Inspectors. During focus groups for this study, some residents told researchers they reported their neighbors for burning out of fear that, in areas where people are living in houses built of wood, fires would start and spread through the neighborhood.

As indicated by the new inspection program, there have been recent efforts within the current City Council to establish a system for enforcing the sanctions provided in the Regulation of Public Services. Thus far, however, enforcement under this program has been inadequate to address the severity of garbage-related violations occurring in Nogales, Sonora. For example, 26 fines were paid for citations issued by Public Services during the 4-month period from March through June 2007, totaling MX $10,936.07 (≈ US $1,013.42) and averaging only MX $2,734.02 (≈ US $253.35) per month.[7] Businesses, both small and large, paid for approximately 1/3 of these fines. Individuals paid for the remaining 2/3 of the fines, for violations including dumping trash and construction materials in the public street. Of the paid fines that had violations noted on record, none was imposed for garbage burning during that period of time.[8]

Personnel from within Municipal Public Services assert that fines are not imposed on individuals who do not have garbage collection service. Another reason for non-enforcement originates from the fact that the inspectors from Public Services are often directed to engage in other types of work apart from their inspection routes, including participating in the citywide garbage clean-up campaigns. REEEP and the Regulation of Public Services both contain provisions prohibiting the burning of household garbage and solid waste, in addition to establishing the legal duties of citizens and the municipal government with regards to solid waste disposal and collection.

Both the REEEP and the Regulation of Public Services give respective departments of the municipal government the power and duty to establish inspection teams to carry out enforcement of its laws. The Department of Planning, Urban Development, and Ecology and the Department of Public Services have recently collaborated to create a new inspection program to increase enforcement of garbage-related violations. However, this enforcement effort has thus far been inadequate to address the severity of garbage-related violations in Nogales. Due to the fact that many people who violate the regulatory provisions concerning garbage dumping and burning do so because garbage collection service in their neighborhood is either irregular or nonexistent, it is generally considered unjust to enforce sanctions on such individuals.

In order for enforcement efforts to be effective as a deterrent for garbage-related violations in Nogales, there needs to be significant improvement of the garbage collection infrastructure. Additionally, the city and community partners need to organize educational campaigns to inform citizens of the alternatives to negative waste disposal practices. Only after such changes have

[7] Reporte de Ingresos por Concepto de Multas—Servicios Públicos del 1/03/07 al 27/06/07 [Intake Report for Public Services Fines from 3/1/07 to 6/27/07] (June 27, 2007) (on file with the Municipal Treasury Office of Nogales, Sonora).
[8] *Id.*

been made will an enforcement program make a significant impact on solid waste management in Nogales, Sonora.

The current program in place for enforcement of the Regulation of Public Services, though inadequate at this point due to current circumstances and priorities, could potentially be adequate if certain basic necessities of the citizens of Nogales were fulfilled, including sufficient garbage collection service and containers. Finally, once the citizens of Nogales are receiving adequate garbage collection service and information about the hazards of open-air burning, it would be appropriate to increase enforcement efforts to combat any remaining violations of the garbage dumping and burning bans in the existing local laws.

Controlling Dogs

The Department of Public Services has also started a new program to control the street dogs in Nogales. Two people have been hired to round up street dogs. They have a truck and the equipment to catch the dogs. If someone's dog is captured, the person must pay a fine to get his or her dog back. If this program is successful, it could reduce the number of dogs that get into trash and spread it around the street.

Public Education and Outreach

As noted in Chapter One, public education and outreach are key components to the success of any public program. City officials have placed information in local newspapers and radio programs describing the new waste management systems in Nogales. They have also conducted a series of public meetings to discuss the information from their studies and presented their plan of action. For all of the above mechanisms to reduce burning, those implementing the programs will need to follow through with public education and outreach to make sure residents are informed of the changes in MSW management.

Wood Burning

In a previous study (see Austin et al. 2006), researchers assessed approaches for reducing emissions generated by the use of wood and other combustible materials as fuel for household-level heating and cooking in Nogales, Sonora. Because numerous alternative stove technologies have been designed and studied, several alternatives were identified. Guided by interviews, household visits, and focus groups, the research team selected two energy-efficient, low-emissions stove designs as most likely to be appropriate for Nogales: (1) solar ovens and (2) rocket elbow stoves. The team also developed a second, portable version of the rocket elbow stoves. In total, 56 households received stoves and monitored their use of them for a period up to six months. Participants used monitoring forms to record their stove use and cooking patterns for at least two months and researchers visited each household at least once every three weeks to discuss the stoves and to make sure that proper documentation protocol was being implemented.

Alternative Stoves

Solar Hotpot

One of the cooking technologies pilot tested was the Solar Hot-Pot.[9] This study took place from summer 2006 until spring of 2007 in two different neighborhoods on opposite sides of the city of Nogales, Sonora. The neighborhoods differ greatly in age and are occupied by residents of slightly different socioeconomic levels, with the newer one having residents of lower socioeconomic status.

There were two phases of testing for solar cookers that were introduced first in December of 2005 and distributed in March of 2006. As a continuation of this project, 33 more solar hot-pots were distributed within these two communities in the spring of 2006. Participants in the previous phase of the project were enlisted to help in the monitoring process. The monitoring process required Hot-Pot users to fill out two different forms, one containing information on the specific process of cooking with the solar Hot-Pot and the other with information about their general habits of cooking and use of other combustibles. Community monitors were recruited, one for each of the two communities, to help collect the monitoring forms from the users. In the second phase of this project, monitoring continued from May 2006 until the end of October 2006.

A series of exit interviews were conducted with the hot pot users in November and December of 2006 to assess the project and plan for future actions. These interviews focused on the particularly active users or users who had not reported much usage. Because of a clear decline in Hot-Pot use during the winter months, after those months had passed, in April and May of 2007, another 15 interviews were conducted with participants to determine whether or not they had started using the Hot-Pots again, if there were any new problems, and if participants who had not been frequent users planned on trying again this year or if they would be willing to donate the Hot-Pot to another family. This process was also part of setting up an event in which to gather the solar users together and share experiences and recommendations as part of a larger project to assess the feasibility of a small enterprise to distribute Solar Hot-Pots in the city of Nogales.

Participants exhibited great variety in their use of the Solar Hot-Pot. During May 2006, users reported using the Solar Hot-Pots 286 times. The most prolific user used cooked 72 meals in a four month period whereas other users reported three or fewer usages.[10] Seasonal variations also exist. The greatest use occurred during June. During the monsoon season in July and August, as well as during the fall months of September and October, participants reported decreased use. Researchers also found that participants were slow to resume use after a period of non-use.

Explanations for non-use included complaints that the weather was unsuitable, despite the successful use of the Hot-Pots at demonstrations, and that the reflector had been damaged or destroyed by rain, sun, or wind. Those who reported the highest levels of solar cooking in the first year reported damage to their reflectors, including delamination due to exposure to water, ripped tabs, and a streaking affect, where the reflective surface appears to have been washed out by the sun. Further testing should reveal why and how these reflectors are getting damaged, but it

[9] Thanks to Solar Household Energy, Inc. for donating the Solar Hot-Pots to the residents for the study.
[10] Some of these women left the area and were not monitored

is clear that cardboard is not durable enough. Solar Household Energy, Inc. sent 25 replacement reflectors to Nogales, Sonora where they are waiting to be distributed to Hot-Pot users.

Though all users had attended workshops when the received their stoves, several problems or misunderstandings were reported to the researchers and may have contributed to the great variation in usage. Some people reported hearing that the Hot-Pots can cause cancer. This rumor was quickly dispelled during workshops and home visits, but mistrust remained within the community about use of the sun's rays, which people are aware can cause skin cancer, for cooking food. Others reported that they or their families did not like the taste of the food cooked with the Hot-Pot and would therefore only use it for specific foods such as beans or rice. However, the high levels of enthusiasm demonstrated by some participants indicate there is the potential for future use of the Hot-Pot in Nogales Sonora.

Because participants discontinued their use during two periods of the year – summer monsoon rains and then winter months – it is difficult for use to become habitual. Restarting was a problem after each period of non-use, and few people restarted after the second period of non-use, despite researchers' visits to their homes to find out if they were using the Hot-Pot and discuss restarting. It is clear that even after a lengthy period of monitoring, during which Hot-Pot users reported their daily use of the Hot-Pot and were visited weekly, participants did not become habitual Hot-Pot users. A longer period of introduction, coupled with local interaction with other Hot-Pot users, will be necessary for the new technology to take hold. Also, a more durable reflector is needed, or at least an easy mechanism for users to get a replacement for their damaged and worn reflectors.

Despite concerns about seasonal functionality, resumed use, and durability, Solar Hot-Pot users consistently inform UA researchers of other people interested in using the Hot-Pot and state that they would recommend it for use or sale in the city. One woman even lent her solar cooker to others to try and learn for themselves about how it works. Some women have expressed interest in starting a small enterprise and investigation on startup costs, as well as the possibility of connecting the business to a local micro credit lending organization.

Urban Rocket Elbow Stove

Burning wood as a source of fuel contributes to poor air quality in Nogales. However, wood burning is a common alternative in Nogales, Sonora, especially for families who cannot consistently afford to buy gas or for families who do not have gas stoves. Previous studies found that families in Nogales tend to use a variety of stoves so that they can remain flexible to changes in fuel price and availability, seasonal heating needs, and different cooking (Austin et al. 2006). For these reasons, stoves with a rocket-elbow design, which burn more efficiently and with reduced emissions, have been investigated. Researchers found that many families consistently used the low-emissions alternatives that were introduced (Austin et al. 2006).

During the Alternative Technologies project from 2005-06, two types of wood-burning stoves were introduced in two Nogales, Sonora neighborhoods: the Estufa Justa (a brick-and-mortar based stove constructed in Nogales using a design by the Aprovecho Research Center in Cottage Grove, Oregon), and the Eco-Stove (a portable, metal version of the Estufa Justa designed and

constructed in Nogales based on models from Brazil and Nicaragua). The stated benefits of the rocket elbow stoves are that they create less smoke, use less wood, are affordable to build, can be built (albeit permanently) inside or outside the house, are safe for children and stove users, are attractive, and provide heat in the winter. In addition, users reported they would feel comfortable leaving the stove burning overnight, the soot/ash cleans easily, and the stove is easy to light.

Four Estufa Justas and three Eco-Stoves were distributed during workshops and monitored throughout spring and summer of 2006. The stove users provided various suggestions for creating a new stove model using the same rocket-elbow design.

The main complaint about the Estufa Justa was that it was a permanent fixture. Made from cement, brick, and metal, once constructed, it would have to be completely disassembled and rebuilt to be moved. Because of Nogales' extreme temperatures (over 100 F in summer and below freezing in winters), residents wanted to be able to move the stove inside to warm the house during the winter and to move it outside the house during the summer so as not to increase heat inside the house. Also, housing construction in Nogales is often an on-going process, and a house may undergo several changes before it is finished. For example, a kitchen may change places in the layout of the home, and a permanent Estufa Justa would not easily allow for such changes. The initial Eco-Stove was made from metal and was easily moveable, but it was too low to the ground and had too small a cooking surface to efficiently make a family meal. Therefore participants suggested making a portable stove with a larger cooking surface. Another complaint was that the brick Estufa Justa was intended for rural areas. Because Nogales, Sonora is an urban environment, residents wanted a stove that looked similar to conventional gas and electric stoves in use in the city.

In the summer of 2007, the research team collaborated with local metalworkers to improve the original Eco-Stove rocket-elbow design and tailor it to the needs of Nogales residents. Two different models were developed: one with a round cooking surface and one with a rectangular surface. The stoves with a round cooking surface use an old tire rim for the inside chamber which holds the rocket elbow and the ash. Both models use the shell of non-functioning washing machines as the outer base for the stove. Not only did this help to reduce construction costs, but it also provided a use for washing machines that take up space in people's houses, or are thrown in clandestine dumps or on hillsides. One of the benefits of this new design is that the stove's cooking surface increases without adding to the amount of wood that is being burned.

Community participants were solicited to test the new stoves through a local radio program (97.5 FM). Potential participants were asked to be current wood-burning stove users, to provide a non-working washing machine, and to participate in the monitoring process. In October 2007, five community members attended a workshop regarding the stove project and how to use the new stove. They received stoves and will monitor them through the fall of 2007. Additional efforts are underway to share information about the stoves through workshops and public presentations.

Financing Alternative Stoves

In February 2007, members of the UA research team contacted and met with the Secretaría de Desarrollo Social (SEDESOL) in Hermosillo to find out what assistance might be available for Nogales residents wishing to start a micro-enterprise to make efficient wood-burning stoves there. Expressing interest in the possibility, SEDESOL officials suggested that the first step would be to identify a community member who would make the stoves. In August 2007, UA researchers contacted EnComún de la Frontera, A.C. (previously BanComún), a non-profit group with offices in Nogales, Sonora and Ciudad Juarez, Chihuahua. The group offers small ($50-800 USD) loans to community groups to start or improve small businesses. Therefore, a metalworker who wanted to start a small business making and selling either the wood-burning stoves or solar Hot-Pots could investigate this possibility with EnComún. However, EnComún's loans are given on a community basis, meaning each community member seeking a loan must first join a group of others in their colonia who are also seeking a loan, and this group may apply for a loan together. Then each person in that group is responsible for all other group members. This helps to ensure loan repayment without a need for collateral upfront. An individual without access to a community group would not be able to receive a loan from EnComún. Finally, with the help of a UA intern, World Vision began incorporating information about solar cooking alternatives and Eco-Stoves in its workshops for colonia residents and, depending on the outcome of these initial education efforts, may help finance the purchase of these alternatives for interested residents.

Thermally Efficient Construction

As noted above, in an earlier study to investigate alternative construction technologies, Fibrous Concrete (ConFib) was identified by Nogales residents and leaders as the most appropriate for meeting the housing needs of local people that is thermally efficient and low-cost. Because of its high insulation value, ConFib houses should require less heating during the winter. For Nogales residents who use wood to heat their homes, this will mean less burning. As two homes are set to be finished in December 2007, the research team will be able to test ConFib's thermal value during throughout the winter.

Summary

For the most part, people burn garbage and wood in Nogales in order to address specific problems – the lack of garbage collection service or of alternative sources of fuel for cooking and heating. As demonstrated in this chapter, various approaches were taken to address these problems and the larger issues related to improving MSW management in the city. Based on the success of these measures and their potential for reducing burning, researchers then worked with members of the project Advisory Board and other municipal officials to develop an Action Plan for Reducing Burning in Nogales. This plan is presented and discussed in Chapter Six.

Chapter Six: Plan of Action for Reducing Small Scale Wood and Garbage Burning in Nogales, Sonora

The goals of this study included determining how, where, and why residents burned wood and garbage within the city and, based on these data, finding solutions to reduce people's need or desire to burn these items. The research team conducted surveys, questionnaires, interviews, focus groups, and direct and participant observation to (1) document the current situation, and (2) find practical, as well as socially and culturally acceptable, solutions to improve the situation.

As noted in Chapter One, it has proven necessary to design waste management programs that respond to the specific characteristics and needs of the communities within which the programs will operate. An integrated view of all waste management activities is necessary because changes in one aspect of a waste management program will affect others as well. This chapter outlines the Plan of Action for Reducing Small-Scale Wood and Garbage Burning in Nogales, Sonora (see Table 6.1 at the end of this chapter for a summary of the plan). The eight items of the plan are: (1) Improve garbage collection and street cleanliness; (2) Increase capacity and improve management of the landfill and transfer station; (3) Develop a program to facilitate and promote composting; (4) Develop a program to facilitate and promote recycling; (5) Investigate and develop options for increasing the number and type of garbage containers; (6) Develop and promote alternative no-or low-emissions stoves; (7) Develop and implement education and outreach programs; and (8) Investigate the use of legal measures and fines to deter burning. Each action is discussed separately with information about the links between the action and the ultimate goal of reducing burning and improving air quality, recommendations for each action item, the entities responsible for carrying out the recommended action, the information and resources needed for implementing the action, and a timeline for completing the action.

1. Improve Garbage Collection and Cleanliness of Streets

As shown in Chapter Four, there is a strong correlation between high incidence of garbage burning and the quality and regularity of garbage service in Nogales, Sonora. Therefore, one of the key actions is to improve garbage collection services, including efficiency, frequency, and quality of service. Success in this action requires participation by the municipal government, including supplying personnel and soliciting funding.

Action Item A: Improve Garbage Collection

- Redesign routes: The municipal government redefined the garbage routes, which now total 53. Officials divided the city into three sections. Neighborhoods within each section will receive collection on the same days each week, reducing the amount of time collectors spend driving around the city between the neighborhoods and the transfer station. Fifty of the new collection routes are due to receive trash service twice a week, and the other three will get daily pick-up. The new schedule went into effect on June 18, 2007, but was not fully implemented until new trucks were secured. The municipal government will monitor the effectiveness of the new routes and adjust as necessary.
- Purchase new collection vehicles: The municipal government bought 12 new trucks (each with a capacity of 20 cubic yards) that were put into use beginning fall 2007. In June 2008 they will purchase and receive 4 new trucks, each with a capacity of 10 cubic yards.

Action Item B: Increase Cleanliness of the Streets

- Conduct street cleaning campaigns: The Departments of Public Services and Social Development have implemented a program in which residents can arrange a clean-up campaign in their neighborhood. Two types of campaigns are: (1) Collection of large items that are not normally picked up by garbage collectors, such as furniture, pallets, large toys, and branches; (2) Community clean-up involving collection of trash on the street, sweeping, raking, and other general clean-up activities.
- Purchase street sweeping equipment: Two street-sweeping machines were purchased in fall 2007. These are used three times a week on the main streets (Periférico, Avenida Plutarco Elías Calles, and Avenida Obregón). People who used to sweep these streets are now hired to clean the secondary streets downtown.

Recommendations: The Municipal Government should continue to implement the new collection and clean-up campaigns and should also monitor the success of the above action items in reducing the need to burn garbage. Once use of the new routes was begun, some residents interviewed by the research team noticed an increase in the frequency of their garbage collection. The street cleaning campaigns are generally well accepted; however, the Department of Public Services should enhance communication with neighborhoods with scheduled clean-up days.

Entities responsible for completing and monitoring this Action Item include the Municipal Government, specifically the Department of Planning, Urban Development, and Ecology and the Department of Public Services. Resources will be provided by the Municipal Government, from the North American Development Bank (NADB or *Banco de Desarrollo de Norte America, BANDAN*), from the Solid Waste Environmental Program (part of NADB), and from Nogales residents via the 15 peso-per-month trash collection fee which was implemented in 2007. This action item will be ongoing.

2. Increase Capacity and Improve Management of the Landfill and Transfer Stations

The transfer station is currently being used as a landfill, even though no garbage should remain there. The actual landfill does not comply with environmental regulations; it remains open to the air, has no environmental monitoring, and has no mechanism for capture and treatment of leachates. By improving the capacity of the landfill and the management of the transfer station, Municipal Solid Waste will move more efficiently to its final stop and will not pose as great environmental threats to the air, soil, and groundwater. Also, there will be less incidence of burning at the transfer station, as the amount of trash left there, and the need to burn it, will be significantly reduced.

Action Item A: Close Current Transfer Station/Build New Transfer Station

The government has closed down the previous transfer station that was located in the Colonia Bella Vista. The municipal government has already secured the land for the new transfer station. This spot is much closer to the landfill. Municipal government officials plan to buy five storage tanks and a new trash compactor with the capability of moving through 60 tons of trash per hour. The system will be set up to take data such as weight and amount of trash and is expected to cost around 11 million pesos.

Action Item B: Close Cell A at the Landfill/Open New Cell B
Municipal government officials plan to close the current cell, cover it with natural and/or synthetic materials, and construct a new cell next to the existing one. They will first conduct a series of geological, hydro-geological, topographical, and geotechnical studies at the site.

Recommendations: The municipal government should proceed with plans to close the current landfill and open a new transfer station and landfill. Responsible entities include the Department of Planning, Urban Development, and Ecology and the Department of Public Services in Nogales, Sonora. Funding will come from the loan from NADB, SWEP, and BECC. This Action Item should be completed by spring 2008.

3. Develop a Program to Facilitate and Promote Composting.
This program would involve the separation of organic and inorganic garbage, and using the appropriate organic waste to make compost. An education program about composting has two advantages – not only does it reduce the amount of waste that ends up in the landfill, but residents will be able to use the compost to plant trees and create green areas in their neighborhoods. Twenty percent of people who reported burning garbage in the survey said they burn food. One reason for this is that the food attracts dogs, which then spread the trash around in the street trying to eat that food. With the food removed, the garbage may attract fewer dogs. Thus, composting could help reduce the need to burn by removing some of the food items that attract animals. Composting could also significantly reduce the amount of garbage that ends up in the landfill. Unless a citywide program is introduced however, scattered household composting efforts will most likely not have a significant effect on reducing garbage burning.

Action Item A: Implement Citywide Education Programs through the City Nursery
With the help of government officials, a citywide educational program could be started through the city nursery. Nursery employees could hold weekly or monthly workshops and/or provide pamphlets with information on how to compost. When they give or sell plants to schools or neighborhoods, they could give a bag of compost with each plant with instructions on how to use and make compost, emphasizing the benefits not only for the plants, but also for reusing trash and keeping Nogales clean.

Action Item B: Institute Neighborhood Composting Workshops
Composting could also be implemented by city nursery employees through composting workshops in different neighborhoods, demonstrating how each household can reuse its organic garbage. The city could partner with non-governmental organizations such as World Vision, which already has educational programs set up in several Nogales neighborhoods, the majority of which have been identified as high-poverty areas (see Chapter Five).

Recommendations: Initial contact has been made between World Vision and city nursery employees through the July and August workshops. World Vision works in colonias where burning tends to occur with higher frequency. Composting workshops in these areas could help to reduce the amount of trash being burned. A more formal relationship between World Vision and city nursery employees could be established to implement an educational composting program; the program could be citywide or on a household level, or both. University of Arizona

(UA) researchers will maintain communication with the city and World Vision and will document progress of any workshops that are developed.

Responsible entities are the UA, the Department of Ecology, and the City Nursery. Assistance will be sought from non-governmental organizations such as World Vision. The timeline for this project is through spring 2008.

4. Develop a Program to Facilitate and Promote Recycling

There are two ways to promote recycling in Nogales. One is through a more formal municipal recycling program involving the exchange of recyclable materials for money or other incentives. The other is to find new local uses for waste items. Both of these are important options to reduce waste by adding value to items commonly thrown away, such as aluminum, paper, plastic, and glass bottles. Paper is commonly burned in Nogales, so finding alternatives for waste paper, especially in the high-poverty neighborhoods, is likely to help reduce burning.

Action Item A: Initiate a Municipal Recycling Program

The municipal government has set a goal of recycling at least four tons of trash per day until September 2009 when the current government officials will leave office. Two programs will be put in place. The Eco-Peso program involves working with existing local recyclers at whose shops residents can drop off their recyclable items and receive not only the money they would normally get but also Eco-Pesos, which are worth 10 pesos each toward the payment of various municipal services (*tramites*). These Eco-Pesos are transferable; therefore someone who does not need to pay a transaction fee could sell or trade them.

A second program involves establishing school recycling programs, in conjunction with larger commercial recyclers (i.e. Recicladora del Yaqui) within Nogales, Sonora, to collect and recycle plastic and paper. The city will use the money earned to build parks and soccer courts.

Action Item B: Collecting Materials to be Managed Locally

As local interest in Fibrous Concrete (ConFib), an alternative building material, continues to expand, the collection of paper in Nogales to make these ConFib bricks should be further investigated. A member of the Advisory Board for this Small Scale Burning study suggested establishing a collection center for paper, and to reduce risk of fire during storage, mixing the paper with water until it is a pulpy substance and letting it dry into a sort of paper bullion. These bullions of paper could be sold at a low cost to those interested in making ConFib; users would only have to add water, sand, and cement. Another idea is to find someone who will make and sell bricks; however, for either idea to work there must first be a market for ConFib.

Recommendations: The municipal government should continue to investigate the use of benefits/rewards to encourage residents to bring them to collection centers. The municipal government will be in charge of initiating a municipal recycling program, including implementation, monitoring, and financially responsibility. The effort will continue through September 2009. A neighborhood level campaign to collect paper should be evaluated. The Advisory Board member along with researchers from the UA and community members in Flores Magón will be responsible for the next phase of this project. The Board member is currently building a ConFib house. Once it is built, he will investigate the possibility of collecting paper

and storing it as paper bullions. Resources for these actions will come from the municipal government, the UA, and Nogales residents. Additional funds are being sought from private foundations. The project will continue into spring of 2008.

5. Investigate and Develop Options for Increasing the Number and Type of Garbage Containers.

This action involves investigating what types of containers are most useful for efficient waste management and for the community. Many people burn garbage because they do not have a place to store it, or because their trash cans get full, especially if the garbage collectors do not come regularly. Therefore, if residents had consistent access to a public storage container for garbage, the incidence of garbage burning may be reduced.

Action Item A: Install Public Containers

The Department of Public Services has planned to install between 100-120 containers, ranging in size from 1-3 cubic meters, in various communities in Nogales. The Department has contracted with a private company to collect from these public containers. To pilot this project, the company has placed 30 containers and has a truck that collects daily from each of these containers. The Department has also installed 20-40 permanent trash containers (about 55-gallons each) in downtown Nogales since the spring of 2007. These containers are cemented into the ground to prevent theft, but are equipped with garbage bags for easy collection. Garbage is collected everyday from these cans, as they are mostly along main streets in the downtown area.

Action Item B: *Construct Enclosed Garbage Collection Areas*

Improved availability and use of garbage containers will only help reduce garbage burning if the trash collection is also improved; otherwise the garbage will continue to accumulate in one spot. Through monitoring the three sites established in Colonia Artículo 27 as part of the pilot study (see Chapter Five), research team members observed that the collection spots were working, even in the case where the trash cans had been stolen. In that case, residents still place bagged trash inside the fenced area and reported that the collectors came to pick it up from the collection site. Enclosed garbage collection areas provide a stop-gap measure in neighborhoods where residents lack sufficient containers for storing garbage between pickups.

Recommendations: The municipal government will be responsible for implementing its public container program in Nogales, for monitoring the use of the containers, and for collecting data to document the program's success. Residents can organize and collect materials to build an enclosed garbage collection area or can ask for assistance from the municipal government through a Miércoles Ciudadanos meeting (see Chapter Five) or from their Neighborhood Association (Asociación de Vecinos). Resources for both types of containers will come from the city and possibly the private company contracted to pick up the garbage from these containers. This project will be ongoing.

6. Develop and Promote Alternative No- or Low-Emissions Stoves

To continue with ideas from existing initiatives and to increase the distribution of alternative stoves that reduce air contamination and of information about them, two types of stoves should continue to be developed and promoted in Nogales. Stoves that use solar cooking technology, such the Solar Hot-Pot described in Chapter Five, were tested in two Nogales, Sonora

neighborhoods. A modified version of the Eco-Stove, an efficient wood-burning stove using rocket-elbow technology and also described in Chapter Five, was developed and tested in eight households in Nogales. Residents of Nogales, Sonora continue to show interest in alternative cooking technologies.

Action Item A: *Continue to Develop the Urban Rocket-Elbow Stove*
Eight newly designed urban rocket-elbow stoves were constructed in Nogales during the summer and fall of 2007 and distributed in Nogales during the fall. The households with the new stoves require continued monitoring to (1) ensure the stoves are functioning and being used properly, (2) to record the benefits and disadvantages of the new model, and (3) to receive suggestions for design improvement.

Action Item B: Continue Distribution, Testing, and Promotion of the Solar Hot-Pot
Nogales residents in two colonias expressed interest in distributing the Solar Hot-Pot. Participants who monitored their use of Solar Hot-Pots also continue to express interest in starting a small enterprise in their own neighborhoods. A local businessman in the downtown Nogales area is interested in selling these out of his store. A significant limitation in the potential of the Solar Hot-Pot to reduce wood burning for cooking in Nogales is the cost of the stove, so further efforts to obtain and distribute the stoves in the households where they are most needed to reduce wood burning will require programs to help with financing.

Seasonal disruptions also continue to be a problem with Hot-Pot use, and lack of space and theft if the hotpot is left outside unattended are equally serious problems. UA and ITN faculty have begun discussions of a design for a house made of ConFib (see 4B above) that would include a roof-level space for a solar cooker that is not readily accessible from outside the house and therefore also more secure.

Recommendations: The UA researchers should continue monitoring the urban rocket-elbow stoves and continue to search for metalworkers interested in creating a small business building and selling stoves. They and other interested parties should continue investigation of funding mechanisms that will enable local residents to purchase alternative cooking technologies and/or to develop their own microenterprises. They also should continue to monitor how much people are willing to pay for either the Solar Hot-Pot or the urban rocket-elbow stove. Responsible parties include the UA and local metal workers, with resources being sought from potential lenders such as SEDESOL, EnComún, and World Vision.

Since members of the UA research team conducted the radio interviews in the summer of 2007, radio and television stations in Hermosillo have invited the research team to talk about the projects. After further monitoring of the stoves in the community the research team will revisit the idea of an interview in Hermosillo. In addition, UA researchers were told that Sonoran state government officials learned of the radio interviews and have expressed interest in the rocket elbow stoves for the rural parts of Sonora. The research team has also been invited back to the studio of the local radio station in Nogales, Sonora to talk about the stoves and other projects being undertaken with the assistance of the Bureau of Applied Research in Anthropology (BARA) at the UA.

7. Develop and Implement Education and Outreach Programs

One way to disseminate knowledge about air quality and its connection with burning garbage and wood is to involve schools and public media, such as the radio. Especially in border communities where a large proportion of the population is transient and there is high turnover every year, ongoing education and outreach is critical to the success of the other programs.

Action Item A: Develop Campaigns to Promote Recycling Among Schoolchildren

Nogales municipal government officials will work with state and federal officials, as well as with schools and private groups, to develop materials and activities that promote the various programs named above. One example is a citywide art contest for fourth through sixth graders related to the topic of recycling; for this contest the students create items made of recyclable materials.

Action Item B: Develop Radio Messages about Reducing Wood and Garbage Burning

Another action involves creating short radio shows regarding different environmental issues and activities to improve the environment. Groups of students will create, write, and act out the radio shows, which will be transmitted in Ambos Nogales. One radio station has expressed interest (97.5).

Recommendations: The municipal government has promoted the recycled art contest, and all Advisory Board members should help publicize and support it. With the help of Nogales community leaders, UA team members began conducting radio interviews about alternative stoves and reducing wood burning in the summer of 2007. Representatives from the Arizona Department of Environmental Quality (ADEQ) have begun to contact interested teachers in Nogales, Sonora to implement the student program to develop specific educational radio spots. Responsible entities are the municipal government, schools, ADEQ, and the Instituto Tecnológico de Nogales. Resources will come from the municipal government and ADEQ. These actions will be finished by May 2008.

8. Investigate the Use of Legal Measures and Fines to Deter Burning

In focus groups, many residents suggested that the municipal government should apply fines to people who threw trash in the streets or canyons near their homes. The first action related to this suggestion is to investigate the possibility of applying fines in Nogales and understanding the current system.

Action Item: Investigate Fines in Nogales, Sonora

The investigation portion of this action was funded by the UA and was completed in July 2007. In the summer of 2007, a law student intern from the UA investigated what types of laws exist regarding fines and garbage. Fines are already written into the laws of the city. A squad of 12 inspectors can give fines to people who burn garbage or have garbage around their homes. Residents can call the Citizen Hotline (072) to inform the city officials, who may or may not send an inspector over to check out the situation (see “Legal Measures and Fines” in Chapter Five).

Recommendations: Many people do not know the Citizen Hotline exists, nor do they know there is a system of fines in place, as this was a regular suggestion from community members during

focus groups. The municipal government should investigate ways to publicize information about the Hotline.

Table 6.1. Summary of Actions and their Implementation

Action Item	Timeline	Contact Person	Resources & Funding
I. Improve Garbage Collection and Street Cleanliness			
A. Improve Garbage Collection		Romina Castaños, Urban Development	Municipal Government; BECC; SWEP
1. Redesign routes	5-07 through 9-07	Claudia Gil, Urban Development	Municipal Government; BECC; SWEP
2. Purchase new collection trucks	5-07 through 6-08	Claudia Gil, Urban Development	Municipal Government; BECC; SWEP
B. Improve Cleanliness of the Streets		Romina Castaños, Urban Development	Municipal Government, BECC, SWEP
1. Conduct Street Cleaning Campaigns	5-07 through on-going	Guillermo Barraza, Public Services	Municipal Government; BECC; SWEP
2. Purchase street-sweeping equipment	5-07 through Fall 07	Claudia Gil, Urban Development	Municipal Government; BECC; SWEP
II. Increase Capacity and Improve Management of Landfill and Transfer Stations			
A. Close Transfer Center / Build New Transfer Center	5-07 through Spring 09	Guillermo Barraza, Public Services	Municipal Government; BECC; SWEP
B. Close Cell "A" at the Landfill / Open New Cell "B"	5-07 through Spring 09	Guillermo Barraza, Public Services	Municipal Government; BECC; SWEP
III. Develop a Program to Facilitate and Promote Composting			
A. Implement citywide Education programs through the City Nursery	5-07 through Spring 08	Adriana Guerrero, Ecology Department	Municipal Government
B. Institute Neighborhood Composting Workshops	5-07 through 12-07	Diane Austin and students, UA	UA
IV. Develop a Program to Facilitate and Promote Recycling			
A. Initiate a Municipal Recycling Program	5-07 through 9-09	Adriana Guerrero, Ecology Department	Municipal Government
B. Collect Materials to be Managed Locally	3-07 through Fall 08	Guadalupe Meléndrez, Flores Magón; Diane Austin and students, UA	Colonia Residents, UA

V. Investigate and Develop Options for Increasing the Number and Type of Garbage Containers			
A. Install Public Containers	5-07 through 8-07	Guillermo Barraza, Public Services	Municipal Government
B. Construct Enclosed Garbage Collection Areas	5-07 through 12-07	Diane Austin and students, UA	Colonia residents
VI. Develop and Promote Alternative No- or Low-Emissions Stoves			
A. Continue to Develop the Urban Rocket-Elbow Stove	Through 12-07	Diane Austin and students, UA; Alejandro Castro, metalworker in Nogales	Visión Mundial, SEDESOL, EnComún
B. Continue Distribution, Testing, and Promotion of the Solar Hot-Pot	Through 12-07	Diane Austin and students, UA	EnComún, Visión Mundial, SEDESOL
VII. Develop and Implement Education and Outreach Programs			
A. Develop Campaigns to Promote Recycling Among Schoolchildren	9-07 through Spring 08	Adriana Guerrero, Ecology Department	Municipal Government
B. Develop Radio Messages about Reducing Wood and Garbage Burning	9-07 through Fall 08	Laura Gomez, Arizona Department of Environmental Quality, with UA and Nogales students	ADEQ, UA
VIII. Investigate the Use of Legal Measures and Fines to Deter Burning			
A. Prepare report regarding use of legal measures and fines	5-07 through 7-07	Diane Austin, UA (work by Maya Abela, Law Student Intern)	UA

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Appendices

Appendix A: Household Survey

No. de identificación: _____
Fecha: _____
Entrevistador/a: _____
Colonia: _____
Calle*:* _____

Hola, me llamo_____. Soy estudiante de la Universidad de Arizona y estoy trabajando con estudiantes del Instituto Tecnológico de Nogales para estudiar servicios de recolección de basura y actividades relacionados a la quema de basura y combustibles. Ud. fue seleccionado/a al azar para participar en una encuesta anónima y su participación es voluntaria. La encuesta durará unos 15-20 minutos. ¿Está dispuesto/a a participar?

1. ¿Ud vive aquí? (en esta casa)
2. ¿Me podría Ud responder algunas preguntas sobre su hogar?

Basura

1. ¿Qué tipo de contenedores o bolsas usa Ud para sacar su basura?
   a) Bolsas plásticas de supermercado
   b) Bolsas de basura grande (negra)
   c) Tambos
   d) Otro _____

2. ¿Cuántas de estas bolsas o contenedores llena semanalmente?_____

3. ¿Hay otro tipo de desechos que Ud no pone en estas bolsas (o tambos, contenedores)?
   ¿Cuáles?_____
   ¿Qué hace con ellas? _____

4. ¿Qué pasa con la basura después de que las pone en estas bolsas o contenedores?

5. ¿Usa Ud el servicio de recolección de basura?
   a) Si
   b) No Si o No: ¿Por qué?_____

6. ¿Por dónde pasan los camiones de basura aquí? (*En relación a la casa – encuestadores deben medir la distancia y anotar problemas topográficos*)
   a) ¿Ud tiene alguna dificultad en llevar las bolsas o contendores al lugar de recolección?
   b) Distancia

7. ¿Cuándo fue la última vez que paso el camión de basura?

8. ¿Con qué frecuencia pasan los camiones de basura?
   a) Tres veces por semana
   b) Una vez por semana
   c) Cada 15 días
   d) Mensual
   e) 0tro____

9. ¿Hay días específicos cuando debe pasar los camiones? ¿Cuáles?_____

10. ¿Tiene que estar presente cuándo pasa el camión o deja la basura afuera?
    a) Si – tengo que estar presente
    b) No – no tengo que estar presente

11. ¿Está Ud satisfecho con el servicio de recolección?
    a) Si
    b) No - ¿Por qué?_____

12. ¿Qué tipo de basura no recolecta el municipio? (por ejemplo colchones, llantas, muebles, etc.)

13. ¿Qué hacen con las cosas que no son recolectadas?

14. ¿Existe un tiradero por aquí cerco donde la gente de esta colonia puede tirar su basura? ¿Dónde?_____

15. ¿Quién recolecta la basura que está tirada en la calle? ¿Qué hacen con ella?

La quema de basura

1. ¿Existen ocasiones en las que la gente que vive en esta calle quema basura?

Si –

1.1 ¿Con qué frecuencia sucede?

1. 2 ¿Existen algunos meses del año cuando se incrementa la quema? ¿Cuáles?

1. 3¿Cuándo están quemando, la queman en un tambo o en el suelo?

No – *Pasa a la pregunta 3 sobre el porqué de la quema*

2. ¿A veces Ud. también tiene que quemar la basura*?*

Sí -

2.1 ¿Cada cuanto la quema?

2.2 ¿Dónde la quema con relación a su casa?

2.3 ¿En el tambo o en el suelo u otro contenedor?

2.4 ¿Qué tipo de basura quema Ud.?
a) Papel y cartón
b) Comida
c) Zacate y hojas
d) Plástico
e) Vidrio
f) Otro

No- *próximas preguntas*

3. Nos podría dar su opinión de: ¿Por qué cree la gente tiene que quemar basura?

4. ¿Cuáles cree Ud que son los beneficios de quemar los desechos/basura?

5. ¿Aparte de la basura, hay otras cosas que la gente quema?

Estufas

1. ¿Usa leña para cocinar, por ejemplo en estufa o hornillo de leña, asador, disco, o tambo?
   1.1 ¿Estas están adentro o afuera de la casa?
   1.2 ¿Con qué frecuencia lo/la usa en tiempo de frío?
   a) Todos los días
   b) Mas que una vez por semana
   c) Una vez por semana
   d) Menos que una vez por semana
   1.3 ¿Con qué frecuencia lo/la usa en tiempo de calor?
   a) Todos los días
   b) Mas que una vez por semana
   c) Una vez por semana
   d) Menos que una vez por semana
   1.4 ¿Hay veces en las que Uds queman basura como cartón, papel o plásticos en estas estufas? ¿Qué tipos?

2. ¿Usa estufa de gas para cocinar?
   2.1 (Solo pregunta sobre los dos estaciones si también usa leña.)
   ¿Con qué frecuencia la usa en tiempo de frío?
   a) Todos los días
   b) Mas que una vez por semana
   c) Una vez por semana
   d) Menos que una vez por semana
   2.2 ¿Con qué frecuencia la usa en tiempo de calor?
   a) Todos los días
   b) Mas que una vez por semana
   c) Una vez por semana
   d) Menos que una vez por semana
   2.3 ¿Hay ocasiones en las que se le acaba el gas? ¿Por cuánto tiempo permanece sin gas?
   2.4 ¿Qué hace para cocinar cuando no tiene gas?

3. ¿Usa electricidad para cocinar, por ejemplo en sartenes eléctricas, ollas eléctricas, o microondas?
   3.1 (Solo pregunta sobre los dos estaciones si también usa leña.)
   ¿Con qué frecuencia la usa en tiempo de frío?
   a) Todos los días
   b) Mas que una vez por semana
   c) Una vez por semana
   d) Menos que una vez por semana
   3.2 ¿Con qué frecuencia la usa en tiempo de calor?
   a) Todos los días
   b) Mas que una vez por semana
   c) Una vez por semana
   d) Menos que una vez por semana
   3.3 ¿Hay ocasiones en las que no tiene electricidad? ¿Por cuánto tiempo permanece sin electricidad?
   3.4 ¿Qué hace para cocinar cuando no tiene electricidad?

4. ¿Ud tiene calentón de? leña _____ calefacción de gas _____ eléctrica _____ No calenton___

4.1 Si usa calentón de leña:
¿Cada cuánto usa el calentón en tiempo de frío?
a) Todos los días
b) Mas que una vez por semana
c) Una vez por semana
d) Menos que una vez por semana

4.2 Si también usa otro tipo de calefacción:
¿Cada cuanto usa el _____[otro tipo] en tiempo de frío?
a) Todos los días
b) Mas que una vez por semana
c) Una vez por semana
d) Menos que una vez por semana

Alternativas y sugerencias

Vamos a usar esta información para dar sugerencias para mejorar servicios de recolección de basura y para reducir los efectos de la quema de basura y leña.

1. ¿Cuáles cree Ud que podría ser alternativas eficaces para que la gente no tenga que quemar la basura y la lena?
2. En su opinión, ¿cuál es la forma más eficaz de dar información sobre estas problemáticas de recolección y quema de leña y basura en su colonia?

Muchas gracias. Para terminar, quisiéramos preguntarle algunos datos personales

Datos personales

Género: M__ F__
Edad: _____

1. ¿Cuál es su lugar de origen? _____
2. ¿Hace cuánto tiempo vive en Nogales?: _____
3. ¿Hace cuánto tiempo vive en ésta Colonia? _____
4. ¿Dónde vivía antes? _____
5. ¿Cuántas personas viven en esta casa? _____
6. ¿Cuántas personas de las que viven en esta casa tienen empleo? _____
7. ¿Será que Ud me podría decir en promedio cuanto es el ingreso económico total de este hogar/casa? _____

Observaciones

Calidad de la calle:
Superficie: pavimentada – no-pavimentada
Grado: alta – mediana – baja
Condición: buena – normal – mala
Anchura en relación al camión: suficiente – no suficiente
Comentarios:

Appendix B: Survey Protocols

Overall Goal: Complete 12 surveys within each AGEB unit.

General approach: Within each AGEB unit, randomly select 12 houses. If no one is available at a house, skip it and continue with the random sampling process. If someone is home but not an adult who can complete the survey and no adult will be coming home while you are surveying in the AGEB unit, treat is as if no one was home. If an adult who can complete the survey will be returning (if the individual tells you to come back later) or will be coming home while you are surveying (according to someone at home when you go to the house), return to the house once, at the time the potential respondent is supposed to be home. If no one is available on the second visit, treat the house as if no one was home.

Before dividing into groups:
a. Select the AGEB units in which you will be surveying and determine if you will go alone or in pairs. If more than one individual will be completing the survey within the same AGEB unit, determine in advance which surveyor will use which identification numbers.
b. Make sure you have enough copies of the survey to do all the units to which you are assigned for the day.
c. Using the map with colonias names, make sure you know which colonia(s) your AGEB units are in.
d. Roll dice or draw numbers from a hat (between 4 and 10, or so) to select a random number for counting off houses.

When you enter the AGEB unit:

1. Using the AGEB map that Ben created, get as close as you can to the center he marked on the map.
2. Heading in the direction marked by the arrow (which was determined randomly by Ben), walk until you reach the first street, turn right and, by counting houses on both sides of the street (including those not directly on the street if their occupants must use the street you are on to get in and out of the neighborhood), count off the number of houses indicated by the random number the group selected earlier.

When you reach a designated house:

3. Assign a unique identification number to the household - Use the AGEB unit as your base and then give the household a unique number (e.g., 145-8-1, 145-8-2, 145-8-3).
4. Record the name of the colonia you are in - because the AGEB units are not always matched with colonia boundaries, you will need the maps showing the colonia boundaries and cross check those against the maps of AGEB units you will be using to do the surveys.
5. Knock on the door or call out to determine if anyone is home.
    If no one is home, return to step 2 – continue in the same direction until you reach the house indicated by the random number the group selected earlier. Note, when you reach

the AGEB boundary, turn right and continue counting houses until you reach the house indicated by the random number the group selected earlier. When you cross a street onto which you can turn right, do so. If you make a complete circle within the unit and cross a street on which you have already walked, skip that street and go to the next one and continue down it. If you have walked down all streets within the AGEB unit, go back down the first street on your right and start a second cycle.

6.a. If an adult who can complete the survey is home, continue with the survey. For question 6b, estimate the distance that the garbage trucks pass from the front door of the house, unless the trucks pass closest to the back door. If the latter is the case, note it specifically on the survey form.

6.b. If someone is home but not an adult who can complete the survey and no adult will be coming home while you are surveying in the AGEB unit, skip the house and go back to step 2 to find the next house.

6.c. If someone is home but not an adult who can complete the survey and an adult will be coming home while you are surveying in the AGEB unit, note on the survey form what time to return to the house and go back to step 2 to find the next house.

Upon completing the survey at an individual house:

7. Complete the questions in the box on the last page of the survey

8. In the blank space at the bottom of the page, add any additional comments about the survey, any problems you encountered or concerns you have with the responses you received.

9. Mark the location of the house on your AGEB map by putting a dot and labeling it with the unique identification number for that survey (we will not ever share information about specific households, but we may use this information to create composite responses for areas smaller than AGEB units, so it is important that we know where each household is located).

10. Look over the entire survey and make sure you have filled in a response for every question. If the response was "No," that should be clearly marked. If the response was "No response," that should be clearly marked. If the question was "Not applicable," that should be clearly marked.

Upon completing the surveys in one AGEB unit:

11. Look through all the surveys and make sure each one has a unique identification number and that the location of each survey was marked on the map. If there are any duplicates, change one of them on both the survey responses sheet and the map.

12. Store all the surveys in a safe place.

13. Go to a new AGEB unit and go back to Step 1.

Appendix C: Restaurant Survey
(portions related to the study of small-scale burning)

Numero del Restaurante (vea la lista de contactos):
Nombre de la persona del equipo que hizo esta encuesta:
Fecha:

Hola, me llamo ----------. Soy estudiante de la Universidad de Arizona (o ITN), estoy trabajando en conjunto con el Instituto Tecnologico de Nogales (o la Universidad de Arizona). Estamos haciendo investigaciones para aprender como mejorar la calidad del aire en Nogales. Uno de nuestros proyectos es una investigación para ver la posibilidad de hacer biodiesel, un combustible alternativo, de grasas y aceites deshechas. Otros son relacionados a la quema de leña y el reciclaje. Su participación es opcional, y la información que ud. nos da no será conectado con su nombre o negocio en ningún reporte. ¿Está usted dispuesto(a) a contestar algunas preguntas para ayudarnos con nuestras investigaciones?

1. ¿Por quánto tiempo han tenido ustedes este restaurante? _____

2. ¿Qué tipos de combustible usa ud. para cocinar?

Leña ___sí ___no	Gas ___sí ___no	Estufa electrica ___sí ___no	Otro: _____
(para…) __asador/parrilla __estufa/horno de leña __otro Cantidad? _____	Tamaño de tanque: _____ Frecuencia de cambiarlo: _____	n/a	

Preguntas sobre la recolección de basura….

22. ¿Usa ud. un servicio de recolección de basura (para el resto de su basura)?

___sí (___GEN ___el servicio publico ___Otro_____)

___no (continua a 33)

23.¿Tiene usted algun problema con la recolección de basura?

(comentarios) : _____

_____

24. ¿Con qué frecuencia pasan los camiones de basura?

____más que una vez por semana ___una vez por semana

____menos que una vez por semana ___todos los días (continua a 27)

25. ¿Hay días específicos cuando deben pasar los camiones? ___sí ___no

¿Cuáles?_____

26. ¿Tiene que estar presente cuándo pasa el camión o deja la basura afuera?
____Si ? tengo que estar presente
____ No ? no tengo que estar presente

27. ¿Hay algunos materiales que ud. separa del resto? ¿Cuáles? Y ¿Qué hace con ellos?

	Separa?	¿Y qué hace?
Comida desecha		
Carton		
Vidrio		
Plástico		
Latas		
Otro _____		

28. ¿Ha tenido que quemar su basura alguna vez? ___sí ___no

Appendix D: Interview and Focus Group Questions

Interview and Focus Group Questions -- English

Questions for Interviews

1. Which neighborhoods in Nogales do not have public services (water, electricity, gas, sewage, pavement, garbage collection)?
2. Which programs exist related to garbage collection, recycling, stray animals, and burning within the municipality? What are the names of those programs? (Formal and informal programs.) Who is in charge of those programs?
3. What type of garbage is not collected by the municipal government? Who is in charge of collecting material that is not picked up by the garbage trucks? Who can we contact to get that information?
4. How much of the total municipal government budget is dedicated to programs related to garbage collection?
5. What are the opportunities and challenges for improving garbage collection in the municipality?
6. Are there programs that provide economic assistance for residents to have access to gas?
7. How can people access information about garbage collection, for example when there is a dead dog?

Questions for Focus Group Discussions

1. Why do people burn materials within Nogales?
2. Other than garbage, what sorts of materials do they burn?
3. Who is responsible for garbage collection and dealing with stray animals in the city?
4. How are the colonia leaders organizad? What are the relations between the colonia leaders and the government? Is the new administration working with the leaders of the colonias?

Preguntas para Entrevistas y Grupos Enfocados -- Español

Preguntas para Entrevistas

1. ¿Qué colonias en Nogales no tienen acceso a los servicios públicos (agua, electricidad, gas, desagües, pavimentación de vías, recolección de basura)?
2. ¿Existen programas que trabajen el tema de recolección de basura, el reciclaje, los animales en las calles, y la quema en el municipio? Cuáles son los nombres de estos programas? (Programas formales e informales.) Quiénes están a cargo de estos programas?
3. ¿Qué tipo de basura no recolecta el municipio? Cuáles de los tierreros se encargan de recolectar lo que no se llevan los camiones? Qué personas de los servicios públicos podemos contactar para conseguir esta información?
4. ¿Cuanto del total del presupuesto del gobierno municipal es invertido en programas sobre recolección de basura?
5. ¿Cuáles son las oportunidades y metas para mejorar el servicio de recolección de basura en el municipio?
6. Existen programas que faciliten ayuda económica para tener acceso a servicios de gas?
7. ¿Cómo la gente puede acceder a información sobre la recolección de basura, por ejemplo cuando hay un perro muerto?

Preguntas para Grupos Enfocados

1. ¿Por qué cree la gente tiene que quemar basura?
2. ¿Aparte de la basura, hay otras cosas que la gente quema?
3. ¿Quién tiene la responsabilidad para la colección de basura y el manejo de animales en las calles en el municipio?
4. ¿Cómo está conformado los líderes en las colonias? ¿Cuáles son las relaciones de los líderes de las colonias con el gobierno? ¿Cómo está trabajando este nuevo gobierno con los líderes de las colonias?

Appendix E: Trucks Used for Collection of Municipal Solid Waste in Nogales, Sonora

Figure E.1. Open truck

Figure E.2. Compactor truck

Appendix F: Examples of Stoves Used in Nogales, Sonora Households

Appendix G: Making Fibrous Concrete

Materiales por 1 bloque (15 cm ancho x 30 cm largo x 15 cm de profundidad):

Cemento—12 onzas/340 gramas (línea rosa en la botella de 1 litro) “Type II Portland”
Arena—8 onzas/227 gramas (línea verde en la botella de 1 litro)
Agua—3 litros (1.5 del 2 litro botella)
Papel—9 onzas/255 gramas (2.5 cm? de periódicos aproximadamente)

1. Mezcla el papel con el agua hasta que no se vea ningún pedacito de papel.
2. Agrega la arena y cemento a la pasta de papel y agua y mezcla bien.
3. Prepara el molde en un área seleccionada. Pueden poner plástico abajo del molde, pero no es necesario.
4. Pon la mezcla en el molde hasta que se llene totalmente.
5. Dejá la mezcla en el molde por un día.
6. Cuándo está fime, quita el molde y pon el bloque en su lado, así que puede secar mejor.
7. Después de 2 semanas está listo para usar.
8. Usa una mezcla de confib con más cemento para crear una estructura de los bloques.

Materiales para 1 bloque de (15 cm de profundidad x 61 cm ancho x 91.5 cm largo)
Cemento—144 onzas / 4080 gramas “Type II Portland”
Arena—96 onzas / 2724 gramas
Agua—36 litros
Papel—108 onzas / 2700 gramas

Para hacerlo más fácil y rápido, reparte lo anterior en tres botes:
Cemento--48 onzas / 1360 gramas “Type II Portland”
Arena—32 onzas / 908 gramas
Agua—12 litros
Papel—36 onzas / 900 gramas